GALLAGHER, CALLAHAN & GARTRELL

DONALD J. PFUNDSTEIN
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October 23, 2008

Michael J. Iacopino, Esq.
Brennan, Caron, Lenehan & Iacopino
85 Brook Street
Manchester, NH 03104

Peter C. L. Roth, Esq.
Office of the Attorney General
Site Evaluation Committee Counsel
NH Department of Justice
33 Capitol Street
Concord, NH 03301

Re: Docket No. SEC 2008-02 - Application of Tennessee Gas Pipeline Company For a Certificate of Site and Facility; Concord Lateral Expansion Project; Noise Report

Dear Attorneys Iacopino and Roth:

Enclosed please find copies of the HFP Computer Noise Model Review and Update dated October 22, 2008, the original HFP Report dated June 9, 2008, as well as revised tables and email correspondence referred to in the October 22 HFP Report.

David M. Jones, PE, Senior Project Engineer at HFP and Erik Kalapinski, the author of the Tetra Tech Report dated December 20, 2007 will both attend the Technical Session scheduled for Tuesday, October 28, at 9:00 a.m., in addition to Company personnel.

Sincerely yours,

Donald J. Pfundstein

DJP/skr
Enclosure

cc: Service List

HFP ACOUSTICAL CONSULTANTS INC.

October 22, 2008

Mr. Thomas Fillip
Principal Engineer
Tennessee Gas Pipeline Company
1001 Louisiana Street
Houston, TX 77002

Thomas.Fillip@elpaso.com
(713) 420-5780

Re: Computer Noise Model Review and Update
Concord Expansion Project, Station 270B1
North Pelham, New Hampshire
HFP File No. 6514-1

Dear Mr. Fillip:

As per your request, HFP Acoustical Consultants Inc. ("HFP") has reviewed our previous work involving computer modeling and noise control design for the planned Compressor Station 270B1 ("Station").

1 Background

Tennessee Gas Pipeline Company ("TGP") is planning to build a new compressor station in Pelham, New Hampshire. Prior to HFP's involvement, a sound level assessment was performed for the Station by TetraTech Environmental ("TetraTech"). That assessment proposed a set of noise control treatments that would comply with the Federal Energy Regulatory Commission's (FERC) sound level requirements for the site. However, because of the quiet nature of the existing sound levels in the area, TGP requested that HFP review options for additional sound control treatments that could further reduce the potential Station sound level contribution.

2 Target

The Station is regulated by FERC. FERC's noise regulation is receptor based, and it limits compressor station noise contributions to no more than 55 dBA day-night average (Ldn) or, equivalently, no more than a continuous 48.6 dBA at the surrounding noise sensitive areas (NSAs). There are no other known state, county, or local regulations that apply to the Station site.

3 Previous Work

TetraTech produced the original environmental sound level report for the project. It included sound level measurements of the existing levels and noise control treatment recommendations designed to meet the FERC requirements. The report was entitled "Baseline Sound Survey and Noise Impact Assessment" and was dated December 20, 2007.

HFP prepared a review, a computer sound model, a detailed noise control discussion, and a comparison with several regulations in a technical memorandum with the subject "Computer Noise Modeling," dated June 9, 2008. That memorandum was intended to assist TGP engineers in choosing control treatments for all of the Station's noise sources. It included three different sets of treatments, along with predicted sound levels for each of these cases. A copy of the technical memorandum is attached.

4 Computer Model Changes

Since the June 9th technical memorandum was released, there have been several updates and changes to the computer model, as noted below.

4.1 Updated Noise Model Based on Manufacturer Data for Purchased Equipment

The computer model has been updated with the most current noise control equipment that TGP has ordered. This updated model is based on sound level data from manufacturers for the specific equipment purchased for the Station, rather than the typical or specified equipment data used in previous modeling. Updated manufacturer data has been received for the following equipment items:

- low-noise gas cooler fan with variable frequency drive;
- high-performance acoustical compressor building wall and roof; and
- Solar supplied items, including the exhaust silencer, intake system, and the low-noise lube oil cooler.

4.2 Revised Exhaust System Performance

Solar engineers raised some questions about the required silencer performance requirements as shown in HFP's June 9th memorandum. HFP reviewed the computer noise model data, and determined that the exhaust sound power level carried over from the TetraTech report was higher than the Solar published data. HFP recalculated the exhaust sound power level and the required silencer performance based on the latest Solar sound level data publication, and issued Revision 2 of the June 9th memorandum tables to indicate the change in the required exhaust performances. These Revision 2 tables are attached, along with the original email from HFP describing the difference in the calculated level.

Subsequently, Solar's acoustical engineer, Bob S. Johnson, P.E., reviewed the exhaust sound power levels and emailed his recommendation of the correct sound power level on August 11,

2008. His recommended sound power level was used as the basis for the purchase specification to Solar. His email is attached.

4.3 Results

The predicted compressor station sound level contributions at the nearest NSAs with the as-purchased treatments range from 44 to 46 dB(A) Ldn. These predicted sound levels are well below the current FERC sound level requirement of 55 dB(A) Ldn.

5 Station Blow-down Silencer

For maintenance or other shutdown periods, the compressor and associated piping must be vented to relieve the pressure in the unit. During this operation, the gas is vented through a large blow-down silencer. The current design has placed this silencer about 100 feet west of the compressor building.

Typical blow-down operations are short duration events that last less than three minutes. As such, they are not a significant contributor to a twenty-four hour weighted average like the Ldn. The Station will not be in operation during blow-down events.

The FERC sound level regulation applies to compressor station equipment that is expected to run during typical full-load operation. As a non-continuous or emergency source the station blow-down silencer is not subject to the FERC regulation.

The blow-down silencer has been specified to produce no more than 45 dB(A) at 400 feet during the blow-down operation. Predicted sound levels during the blow-down would range from 41 dB(A) at the retirement community to the north to 35 dB(A) at the residence directly to the east of the Station. Because of the quick onset of the blow-down it is likely that the operation would be audible outdoors at the nearest residences. However, the predicted sound levels are quite low, will be present only for a short time, and are unlikely to cause complaints.

Thank you for the opportunity to be of service. Please call if you have any questions or comments.

Sincerely,
HFP ACOUSTICAL CONSULTANTS INC.

David M. Jones, P.E.
Senior Project Engineer

Attachments:

Report of June 9th, 2008
Revision 2 of Tables 5, 5-1, 5-2, and 5-3, 6, A1
Email Correspondence

Table 5: Noise Control Treatments Required for Cases 1, 2, and 3

Case 1: Base Noise Control Treatments										
		TL, NR, or IL								
	Type	31.5	63	125	250	500	1000	2000	4000	8000
Building Wall and Roof	TL	6	8	12	18	22	25	30	35	35
Building Vent Intake/Exh Silencer	IL	2	6	12	16	22	28	30	28	16
Building Roll-up Door	TL	2	7	12	17	18	19	22	30	35
Turbine Exh Silencer	IL	3	8	14	22	34	32	26	20	13
Turbine Intake Silencer/Filter	IL	2	4	5	9	18	41	46	48	40
Suct: Pipe Lagging/Blanket Treatment	NR	0	0	1	2	8	16	18	20	20
Disch: Pipe Lagging/Blanket Treatment	NR	0	0	1	2	8	16	18	20	20
Specified PWLs	dBA	31.5	63	125	250	500	1000	2000	4000	8000
Gas Aftercooler	97	107	107	101	97	93	91	87	85	83
Lube Oil Cooler	97	103	101	98	95	93	91	89	88	83

Case 2: Three dB Reduction Noise Control Treatments										
		TL, NR, or IL								
	Type	31.5	63	125	250	500	1000	2000	4000	8000
Building Wall and Roof Perf.	TL	6	8	12	**23**	**29**	**35**	**44**	**42**	35
Building Vent Intake/Exh Silencer	IL	2	6	12	16	22	28	30	28	16
Building Roll-up Door	TL	2	7	12	**18**	**20**	**23**	**30**	**38**	**41**
Turbine Exh Silencer	IL	**5**	**10**	**20**	**27**	**39**	**37**	**32**	20	13
Turbine Intake Silencer/Filter	IL	2	4	5	9	18	41	**52**	**51**	40
Suct. Pipe Lagging/Blanket Treatment	NR	0	0	1	2	8	16	18	20	20
Disch. Pipe Lagging/Blanket Treatment	NR	0	0	1	**6**	**16**	**24**	**28**	**30**	20
Specified PWLs	dBA	31.5	63	125	250	500	1000	2000	4000	8000
Gas Aftercooler	96	107	107	101	97	93	91	**86**	85	83
Lube Oil Cooler	97	103	101	98	95	93	91	89	88	83

Case 3: Six dB Reduction Noise Control Treatments										
		TL, NR, or IL								
	Type	31.5	63	125	250	500	1000	2000	4000	8000
Building Wall and Roof Perf.	TL	6	8	12	**25**	**31**	**37**	**46**	**42**	35
Building Vent Intake/Exh Silencer	IL	2	6	12	16	22	28	30	28	16
Building Roll-up Door	TL	2	7	12	**18**	**20**	**23**	**30**	**38**	**41**
Turbine Exh Silencer	IL	**7**	**14**	**20**	**27**	**41**	**38**	**32**	**22**	13
Turbine Intake Silencer/Filter	IL	2	4	5	9	18	**43**	**52**	**51**	40
Suct. Pipe Lagging/Blanket Treatment	NR	0	0	1	2	8	16	18	20	20
Disch. Pipe Lagging/Blanket Treatment	NR	0	0	1	**6**	**16**	**24**	**38**	**30**	20
Specified PWLs	dBA	31.5	63	125	250	500	1000	2000	4000	8000
Gas Aftercooler	91	107	107	**98**	**91**	**83**	**80**	**79**	85	83
Lube Oil Cooler	94	103	101	98	95	**90**	**85**	**84**	88	83

Table 5-1: Model Results, Case 1

	Total	A-weighted Sound Level at Octave Center Frequency									Total
	dB(A)	31.5	63	125	250	500	1000	2000	4000	8000	Ldn

Predicted Level at Each NSA (gray indicates higher than the IL ord.)

NSA 1	**47**	17	29	35	37	39	41	**44**	32	10	**54**
NSA 2	**47**	23	34	35	37	39	40	**44**	32	7	**54**
NSA 3	**48**	24	35	36	37	39	41	**44**	**33**	10	**54**
NSA 4	**48**	26	36	37	38	40	41	**43**	**34**	15	**54**

Illinois State Octave Band Limits, A-weighted Sound Level at Each Octave
Industrial to Residential

		29	41	46	45	44	41	37	33	31

Reduction from Case 1

1	**0**	0	0	0	0	0	0	0	0	0
2	**0**	0	0	0	0	0	0	0	0	0
3	**0**	0	0	0	0	0	0	0	0	0
4	**0**	0	0	0	0	0	0	0	0	0

Increase over Existing, Day

NSA 1	**6**	4	7	6	5	5	5	8	2	0
NSA 2	**3**	8	6	4	2	2	2	10	4	0
NSA 3	**5**	6	9	6	4	4	4	6	3	0
NSA 4	**5**	7	9	7	4	5	3	6	3	0

Increase over Existing, Night

NSA 1	**15**	17	14	18	19	15	13	18	10	1
NSA 2	**14**	20	18	12	12	11	12	17	11	0
NSA 3	**14**	26	24	16	14	11	11	17	12	1
NSA 4	**15**	24	24	20	18	13	12	16	11	2

Increase over Existing, 24-hour Ldn

NSA 1	**11**
NSA 2	**8**
NSA 3	**10**
NSA 4	**10**

Table 5-2: Model Results, Case 2

	Total	A-weighted Sound Level at Octave Center Frequency									Total
	dB(A)	31.5	63	125	250	500	1000	2000	4000	8000	Ldn
Predicted Level at Each NSA											
NSA 1	**43**	16	28	32	34	37	38	36	30	10	**49**
NSA 2	**43**	22	32	31	34	37	38	36	30	7	**50**
NSA 3	**44**	23	33	31	34	36	38	37	31	10	**50**
NSA 4	**43**	24	34	32	34	36	36	36	32	15	**50**
Illinois State Octave Band Limits, A-weighted Sound Level at Each Octave Industrial to Residential											
		29	41	46	45	44	41	37	33	31	
Reduction from Base Case											
1	**-4**	-1	-1	-3	-3	-3	-3	-8	-2	0	
2	**-4**	-2	-2	-4	-3	-3	-3	-7	-3	0	
3	**-4**	-2	-2	-4	-3	-3	-3	-7	-2	0	
4	**-5**	-2	-2	-5	-4	-4	-4	-8	-2	0	
Increase over Existing, Day											
NSA 1	**3**	3	6	3	4	3	3	3	1	0	
NSA 2	**2**	6	5	2	1	1	1	4	2	0	
NSA 3	**2**	5	7	3	2	2	2	2	2	0	
NSA 4	**2**	6	8	4	2	3	2	2	2	0	
Increase over Existing, Night											
NSA 1	**10**	15	13	15	16	12	10	10	7	1	
NSA 2	**10**	18	16	9	9	9	9	10	8	0	
NSA 3	**10**	24	22	12	11	8	9	10	10	1	
NSA 4	**11**	22	22	16	14	10	8	9	9	2	
Increase over Existing, 24-hour Ldn											
NSA 1	**7**										
NSA 2	**5**										
NSA 3	**6**										
NSA 4	**6**										

Table 5-3: Model Results, Case 3

	Total	A-weighted Sound Level at Octave Center Frequency									Total
	dB(A)	31.5	63	125	250	500	1000	2000	4000	8000	Ldn

Predicted Level at Each NSA

NSA 1	**40**	14	27	31	32	32	32	32	29	10	**46**
NSA 2	**40**	20	29	30	32	33	33	33	30	7	**47**
NSA 3	**41**	21	29	31	33	33	34	35	31	10	**47**
NSA 4	**41**	22	31	32	33	33	33	34	32	15	**48**

Illinois State Octave Band Limits, A-weighted Sound Level at Each Octave
Industrial to Residential

		29	41	46	45	44	41	37	33	31

Reduction from Base Case

1	**-8**	-3	-3	-4	-5	-7	-9	-12	-3	0
2	**-7**	-4	-5	-5	-4	-6	-7	-10	-3	0
3	**-7**	-4	-5	-5	-5	-6	-7	-10	-3	0
4	**-6**	-4	-5	-5	-4	-6	-7	-9	-2	0

Increase over Existing, Day

NSA 1	**2**	3	5	3	3	2	1	1	1	0
NSA 2	**1**	5	3	2	1	1	0	3	2	0
NSA 3	**1**	4	4	3	2	1	1	1	2	0
NSA 4	**2**	5	5	4	2	2	1	2	2	0

Increase over Existing, Night

NSA 1	**7**	14	11	14	14	8	5	7	7	1
NSA 2	**7**	16	13	8	8	6	6	8	8	0
NSA 3	**8**	22	19	11	10	6	5	8	9	1
NSA 4	**9**	20	18	16	13	7	6	8	9	2

Increase over Existing, 24-hour Ldn

NSA 1	**5**
NSA 2	**3**
NSA 3	**5**
NSA 4	**5**

Table 6-1: Exhaust System Insertion Loss (IL) and Sound Pressure Level (SPL) Requirements

Case	Type	Insertion Loss (IL) of Exh. System or Linear Sound Pressure Level Requirement at 400'									TOTAL
		31.5	63	125	250	500	1000	2000	4000	8000	dB(A)
Case 1	IL	3	8	14	22	34	32	26	20	13	
	SPL at 400'	69	65	54	43	42	39	34	32	20	46
Case 2	IL	5	10	20	27	39	37	32	20	13	
	SPL at 400'	67	63	48	38	37	34	28	32	20	42
Case 3	IL	7	14	20	27	41	38	32	22	13	
	SPL at 400'	65	59	48	38	35	33	28	30	20	40

Table A1: Exhaust Sound Power Level Calculation and Comparison

Description	Linear Sound Power / Pressure Level at Octave Center Frequency									
	31.5	63	125	250	500	1000	2000	4000	8000	dBA
From Tetra Report, Calculated Sound Power, Unsilenced Exhaust	127	128	127	127	131	128	122	113	101	131.9
From Solar, Sound Pressure Level at 50 ft, Centaur 50	86	88	88	87	94	88	82	70	61	93.3
Stack top sound pressure to sound power factor for 50 feet (15m)	35	dB								
HFP Calculated Sound Power, Unsilenced Exhaust	121	123	123	122	129	123	117	105	96	128.3
Tetra Calculated Sound Power is Greater by:	6	5	4	5	2	5	5	8	5	3.6

Ronald Spillman

From: Ronald Spillman [ron.spillman@hfpacoustical.com]
Sent: Thursday, August 07, 2008 9:30 AM
To: 'Fillip, Thomas M (Tom)'
Cc: 'Moore, Leslee A (Les)'; 'Greg.Blake@ElPaso.com'; 'Dave Jones - HFP Acoustical'
Subject: FW: FW: EP-CON (3E331) Noise Report
Attachments: Report Revision Treatment Cases v2.pdf

Tom,

Dave Jones prepared the information below, and asked me to relay it to you. Dave is traveling today.

Regards,
Ron

Ronald R. Spillman, P.E.
HFP Acoustical Consultants Inc.
6001 Savoy, Suite 115
Houston, Texas 77036
713-789-9400 voice
713-789-5493 fax
Ron.Spillman@HFPacoustical.com

Tom,

Looks like I've gotten to the bottom of this issue. As I mentioned earlier, we had modeled our Case 1 using the TetraTech report as a starting point. We used both their noise control treatments performance and their sound power level data.

I've compared the sound power level that they were using for the turbine exhaust, and it does not seem to match up with the Solar catalog data for a Centaur 50 (please verify that this is the correct turbine model for this station.) I say "does not seem to match up" because Solar gives their data as a sound pressure level at 50 feet from the exhaust stack, rather than as a sound power level. To calculate a sound power level (as used in a computer model) from a sound pressure level (as measured by an instrument) requires a factor that takes into account the size of the noise source, the distance of the sound pressure level measurement, and the radiation characteristics of the source. However, using any standard calculation method the TetraTech sound power level is too high by several decibels. It's possible that they may have included some kind of unstated safety factor, or they used a different source for their noise data.

If we use our calculated sound power level (based on the Solar catalog data), the required insertion loss of the turbine exhaust silencer is somewhat lower, because the starting unsilenced power level is lower.

I have attached revised Tables 5, 5-1, 5-2, 5-3, and 6-1, based on these lower unsilenced levels. The table numbers are analogs to those used in our June report. These tables have revised insertion losses for the exhaust silencer for the three treatment cases discussed in that report. I have also attached Table A1 which shows a comparison of the HFP sound power level and the Tetra sound power. You could run this by Solar to see if they have done any sound power level calculations for their exhaust systems, and what sort of numbers they might expect.

As we discussed in the report, the existing sound levels at the proposed station location are very quiet and there has already been some opposition to the station. Keep that in mind when considering the noise control treatment options.

Regards,

Dave Jones

Fillip, Thomas M (Tom) wrote:
Dave,

Please advise on how this affects your report.

Thanks,

Tom Fillip
Principal Engineer
El Paso Corporation
Tennessee Gas Pipeline Company
1001 Louisiana Street
Houston, TX 77002
Ph: 713-420-5780
Fax: 713-445-9187
Cell: 832-392-6262
E-mail: thomas.fillip@elpaso.com <mailto:thomas.fillip@elpaso.com>

From: Lorraine X. Heikkila [mailto:HEIKKILA_LORRAINE_X@solarturbines.com]
Sent: Thursday, July 31, 2008 11:57 AM
To: Fillip, Thomas M (Tom)
Cc: Blake, Gregory V (Greg); Bruce A. Woodford
Subject: EP-CON (3E331) Noise Report

Tom -

Just wanted to give you an update on the noise report that was submitted for EP-CON (3E331) and re-attached below.

Charlie Malcolm originally stated, "The first is the base level, I am assuming that it will be a standard exhaust and air intake will take care of that option."

After review, Solar has concluded that our standard inlet silencer and filter will work for all three cases. However, our standard exhaust silencer will not work for Case 1.

We are in the process of getting quotes for all three cases from our supplier. Just to give some perspective, I looked at the insertion losses from the Station 264 exhaust silencer and even that silencer design does not meet the insertion loss requirements in the noise report (does not comply in the 31.5 and 8K Hz band for Case 1 and 2). Our noise guru commented that HFP is requiring high insertion losses in the 31.5 Hz band.

I have attached Solar's current noise brochure in case you would like HFP to redo their numbers on Case 1 using our standard exhaust silencer insertion losses:

Bruce will send out a revised change order log as soon as we get the numbers for the 3 exhaust silencers.

Best regards,

Lorraine Heikkila
Project Engineer, Oil & Gas
Solar Turbines Incorporated
Phone: 858-694-6756
Pager: 619-526-9390
Fax: 858-694-6089
Mail Zone: CSC-24
heikkila_lorraine@solarturbines.com

--

David M. Jones, P.E.
Senior Project Engineer
HFP Acoustical Consultants Inc.
6001 Savoy Dr., Suite 115
Houston, Texas 77036
(713) 789-9400 (office)
(713) 789-5493 (fax)

Bob S. Johnson/1G/Caterpillar
08/11/2008 01:36 PM

To Lorraine X. Heikkila/1G/Caterpillar@Caterpillar
cc Ramon Ballard/1G/Caterpillar@Caterpillar
bcc
Subject PD3E331, EP-CON, Exhaust Sound Emissions

Caterpillar: Confidential Green   Retain Until: 09/10/2008

Ref: E-mail, Written by Dave Jones and Sent by Ronald R. Spillman to Thomas M. Fillip, August 7, 2008

Lorraine,

The exhaust sound emissions in the Solar noise booklet are determined by sound measurements taken per ISO Standard 10494. The measurement procedure in this standard obtains the exhaust emission sound power level and requires four measurement positions 20 degrees above the plane of the exhaust duct outlet flange, and four measurement positions 20 degrees below the plane. We treat the sound power level thus obtained as a 90 degree directivity, which is slightly conservative. The sound pressure levels are obtained by extrapolating the sound power levels to a position 15 meters from the centerline of the exhaust duct outlet flange, in the plane of the flange, using hemispherical divergence.

The exhaust octave band sound pressure levels at 15 meters for the Centaur 50 in Table A1 in the referenced e-mail, are correct. However, I would have obtained the sound power levels by using 32 dB (hemispherical correction) as a correction to the sound pressure levels and not 35 dB (spherical correction). With the hemispherical correction, the exhaust silencer insertion losses could be reduced another 3 dB in each octave band.

We use sound pressure levels for the sound emissions from the sound sources of our gas turbines because customers prefer it: they are unfamiliar with sound power levels and are confused by the terms sound pressure levels (SPLs) and sound power levels (PWLs). So, we use SPLs in the noise booklet and let acoustical consultants convert them to PWLs. The noise booklet includes formulae to show the conversion process and this informs the person making the conversion that hemispherical divergence is to be used.

Regards,

Bob J.

Robert S. Johnson, Sr., P.E.
INCE Bd. Cert.
Consulting Acoustical Engineer

HFP ACOUSTICAL CONSULTANTS INC.

June 9, 2008

Mr. Leslee A. Moore, P.E.
Principal Engineer
Tennessee Gas Pipeline
1001 Louisiana Street
Houston, TX 77002

leslee.moore@elpaso.com
(713) 420-4137

Re: Computer Noise Modeling
Concord Expansion Project, Station 270B1
North Pelham, New Hampshire
HFP File No. 6514-1

Dear Mr. Moore:

As per your request, HFP Acoustical Consultants Inc. ("HFP") has completed a computer noise model and noise control design for the new Compressor Station 270B1 in Pelham, New Hampshire.

1 Background

Tennessee Gas Pipeline ("Tennessee") is planning to build a new compressor station in Pelham, New Hampshire. A sound level assessment had been performed for the proposed station by TetraTech Environmental. That assessment proposed a set of noise control treatments that would comply with the FERC sound level requirement for the site. However, because of the quiet nature of the existing sound levels in the area Tennessee has requested that HFP review options for additional feasible noise control treatments that could reduce the potential station contribution further below the FERC limits.

2 Previous Work

TetraTech Environmental produced the original environmental sound level report for the project. This included sound level measurements of the existing levels and a noise control treatment design to just meet the FERC requirements. The results of this report were included in TetraTech's report titled "Baseline Sound Survey and Noise Impact Assessment" and dated December 20, 2007.

3 Computer Model

3.1 Software and Assumptions

HFP has constructed a computer noise model of the proposed equipment at Station 270B1. The model was developed using Cadna/A, version 3.7.123, a commercial noise modeling package developed by DataKustik GmbH. The software takes into account spreading losses, ground and atmospheric effects, shielding from barriers and buildings, and reflections from surfaces. The computer noise model calculations are based on "ISO 9613-2: Acoustics – Attenuation of sound during propagation outdoors." The calculations hold for favorable downwind conditions with a wind speed between approximately 1 m/s and 5 m/s and also hold for "average propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs on clear, calm nights."

Terrain and elevation data were taken from USGS maps. No foliage effects are included in the calculations, to be conservative. As per the TetraTech model, all calculations are for receivers at 4 meters (13 feet) above grade, approximately the height of a second story window.

3.2 Sound Level Data

Sound power level data for the compressor station equipment was taken from manufacturer data sheets or HFP sound level measurements of similar station equipment. The sound power level data for the aboveground piping was based on our measurements of the untreated compressor piping at Station 264 in Charlton, Massachusetts.

3.3 Results

Table 3-1, below, shows the predicted sound levels at each NSA for the three different treatment cases.

3.4 Compared to Previous Work

There is some discrepancy in the results due primarily to piping noise. The discharge piping sound power levels collected by HFP at Station 264 were very high, and even with the TetraTech specified pipe lagging, the discharge piping alone would contribute more than the predicted overall station contribution at the NSAs.

There are significant variations in the sound produced by compressor suction and discharge piping, primarily related to the pipe diameter, flow conditions, piping arrangement, presence of discharge/suction bottles, etc. This makes it difficult to predict the sound level contribution of compressor piping. Generally, well-installed acoustical lagging and blankets are sufficient for the treatment of compressor piping noise.

The TetraTech lagging performance numbers are relatively low in comparison with data from HFP's archive, so that could explain the discrepancy. It is also possible that the Station 264 piping was significantly louder than the piping at Station 270B1 will be.

Table 3-1: Summary of Computer Model Results, Three Cases

	Total	A-weighted Sound Level at Octave Center Frequency									Total
	dB(A)	31.5	63	125	250	500	1000	2000	4000	8000	Ldn
Case 1: Base Case											
NSA 1	**47**	18	30	34	36	39	41	**44**	32	10	**54**
NSA 2	**47**	25	34	34	36	39	41	**43**	33	8	**54**
NSA 3	**48**	26	35	34	36	39	**41**	**44**	**34**	11	**54**
NSA 4	**48**	27	37	36	36	39	41	**43**	35	16	**54**
Case 2											
NSA 1	**43**	19	27	31	34	36	37	36	30	10	**49**
NSA 2	**43**	25	29	30	33	36	37	36	30	8	**49**
NSA 3	**43**	26	29	30	33	36	38	37	31	11	**49**
NSA 4	**43**	28	30	31	33	35	36	36	33	16	**49**
Case 3											
NSA 1	**39**	17	26	29	31	31	31	31	30	10	**45**
NSA 2	**39**	23	27	28	31	32	32	33	30	8	**46**
NSA 3	**40**	24	27	28	31	32	33	34	31	11	**46**
NSA 4	**40**	26	28	29	31	32	32	33	32	16	**46**

4 Targets

Sound level regulations can be divided into two categories: absolute limits which give a maximum allowable sound level, or relative limits which establish a maximum allowable increase in the sound level.

This station is regulated by the Federal Energy Regulatory Commission (FERC), and the FERC noise regulations are the governing regulation at this site. There are no known state noise laws that are applicable to this facility. However, for purposes of comparison and for setting reasonable noise goals, we have included discussion of the Massachusetts and Illinois state noise ordinances in the following sections.

4.1 FERC

The sound level contributions from this compressor station are limited by the FERC noise regulation governing interstate gas transmission compressor stations. The FERC regulation is receptor based, and limits compressor station noise contributions to no more than 55 dBA day-night average (Ldn) or, equivalently, no more than a continuous 48.6 dBA at the surrounding noise sensitive areas (NSAs). There are no other known state, county, or local regulations that apply to the compressor station site.

4.2 Comparison with Massachusetts Regulations

The Massachusetts regulation is based on relative effects of new noise sources. It essentially limits the total environmental sound level with a new noise source in operation to 10 decibels above the L_{90} before the noise source was installed. However, each case is reviewed individually, and Massachusetts regulators have begun targeting a maximum increase in the existing L_{90} of 4 to 6 decibels for the hours between 12:00 am and 4:00 am. There is also a pure-tone limitation that limits the difference between adjacent one-third octave band levels.

4.3 Comparison with Illinois Regulations

The Illinois State noise regulations give absolute sound level limits per octave band. The limit for industrial noise contributions to residential properties are compared with the predicted compressor station contribution in **Tables 5-1, 5-2**, and **5-3**. The octave bands that would not meet the Illinois octave band requirement are shown in gray and bold in the top section of each table.

5 Noise Control Treatment Cases

Table 5, attached, shows the noise control treatment performance requirements for the three treatment cases discussed in this section.

5.1 Case 1: FERC Compliance

The noise control treatments and equipment performance requirements for the FERC compliance case are shown in **Table 5**. The predicted sound levels at each of the NSAs are compared to the existing sound levels and comparison regulations in **Table 5-1,** attached. Shown at the bottom of this table is the expected increase in sound level due to the compressor station, compared to the daytime sound levels, nighttime levels, and 24-hour Ldn.

This case meets the FERC absolute sound level limit at the NSAs. However, the more than 10 dB(A) increase in the nighttime sound levels would not comply with Massachusetts regulations. Several octave bands are higher than the Illinois state regulation. Also, the 8 to 11 dB(A) increase in the 24-hour Ldn would probably raise questions from most FERC reviewers, who tend to flag increases greater than about 9 or 10 dB(A).

5.2 Case 2: Three Decibels Below FERC

Table 5 also shows the noise control treatments and equipment performance requirements to contribute 3 dB less than the FERC limit. The predicted sound levels at each of the NSAs for this case are compared to the existing sound levels and comparison regulations in **Table 5-2,** attached.

This case requires improvements in the acoustical performance of the following four components:

- Compressor building walls and roof – upgraded construction
- Roll-up Door – add roll-up door to the exterior of the building, for a double roll-up door
- Turbine exhaust silencer – improved performance
- Turbine intake silencer – slightly improved performance

The previously specified lube oil and gas coolers are sufficiently quiet that no additional reduction is required for these pieces of equipment for this case.

This case would meet the Illinois and FERC noise limits at the NSAs. However, the increase in sound level, especially during the nighttime hours, might not be approved by the current Massachusetts regulators due to the 10 dB increase in the night time sound levels. The 5 to 7 dB increase in the 24-hour Ldn would not cause most FERC reviewers to take issue.

5.3 Case 3: Six Decibels Below FERC

Table 5 also shows the noise control treatments and equipment performance requirements to contribute less than 6 dB below the FERC limit. The predicted sound levels at each of the NSAs for this case are compared to the existing sound levels and comparison regulations in **Table 5-3,** attached.

This case requires improvements in the acoustical performance of the following components:

- Compressor building walls and roof – upgraded construction
- Roll-up Door – add roll-up door to the exterior of the building, for a double roll-up door
- Turbine exhaust silencer – improved performance
- Turbine intake silencer – slightly improved performance
- Discharge piping – upgraded lagging or the addition of a noise barrier
- Gas Cooler – specify a quieter cooler, add a VFD system, or add multiple noise barriers
- Lube Oil Cooler – specify a quieter cooler, add a VFD system, or add multiple noise barriers

This case would meet the Massachusetts, Illinois, and FERC noise limits at the NSAs. The 24-hour Ldn would increase about 3 to 4 dB(A). This would be considered a barely noticeable increase to most listeners. However, keep in mind that the station would still be clearly audible at the NSAs during quiet periods of the night and early morning.

6 Noise Control Discussion

6.1 Pipe Lagging/Blankets

The suction and discharge piping is the loudest noise generating component associated with the compressor station. Above ground piping should be minimized to the extent possible. All remaining above-ground piping should be fully treated using acoustical pipe lagging, acoustical blankets, or enclosed in a pipe building.

6.1.1 Case 1 and 2

If lagging is used, the piping should be lagged from the building to the point at which the piping enters the ground. Lagging does not usually need to cover valve bodies or pipe-supports, but should extend as close to flanges as possible.

The minimum lagging should consist of (from pipe surface outwards):

- 3 inches of 6 to 8 pounds per cubic foot mineral wool or fiberglass pipe insulation,
- a layer of 1 pound per square foot mass-loaded vinyl,
- and a layer of 0.016" aluminum jacketing.

Due to federal corrosion inspection requirements, it may be necessary to remove the acoustical lagging periodically. If this is the case, acoustical blankets may be preferred due to the ease or removal and reinstallation. These blankets are typically more expensive than lagging of equivalent performance, and do not hold up as well in harsh environments. Blankets must be carefully fitted with no gaps or exposed seams. Often, two-layer systems are used with a bottom 2" blanket covered with a second 2" blanket with mass layer. The seams are staggered to assure that there are no open gaps to the pipe surface.

6.1.2 Case 3

For the Case 3 piping treatments, we would recommend upgrading the discharge pipe lagging to a septum-layer lagging system. This system would consist of, from the pipe surface outwards:

- 2 inches of 6 to 8 pounds per cubic foot mineral wool or fiberglass pipe insulation,
- a layer of 1 pound per square foot mass-loaded vinyl,

- a second layer of 2 inches of 6 to 8 pounds per cubic foot mineral wool or fiberglass pipe insulation,
- a layer of 1 pound per square foot mass-loaded vinyl,
- and a layer of 0.016" aluminum jacketing.

If blankets are chosen for this piping, the blanket system would also need to be a two-layer system with a septum mass layer between the two blankets.

For the Case 3 piping, we would also recommend that all valve bodies and flanges be acoustically treated using acoustical blanket materials.

6.1.3 Structural Isolation of Piping

In order to limit noise radiation from structural supports, the compressor piping should be isolated from pipe supports and other structural contacts using at least 1/4 inch neoprene bearing pads. The stiffness of the neoprene should be chosen so that the static deflection of the pads under the piping loads is about 1/16 inch. Secondary steel elements such as cable trays, pipe racks, walkways, and conduit supports should not be connected to the pipe supports and/or piping.

6.2 Barriers

For Case 3, the additional noise control treatments for the discharge piping could either include upgraded lagging or a noise barrier on the east and north sides of the piping yard. The specific layout of this barrier would depend on the area classification of the piping yard and whether there will be a piping/valve shed roof over the piping yard.

6.3 Cooler Treatments

The previously specified lube oil and gas coolers are very quiet units. There is a possibility that there are not commercially available coolers that will fulfill both the mechanical performance requirements and the quieter sound power level requirement of Case 3.

If quieter coolers are not available, the best noise control treatment for the Case 3 coolers is to use a variable frequency drive (VFD) control system to reduce the fan speed when possible. Because ambient air temperatures are typically much lower at night, the fan speed can probably be substantially reduced during this most noise sensitive time period. Fan noise is highly dependant on tip speed, so slowing a fan down by 50% leads to about a 15 dB reduction in the fan noise. It is better to reduce the speed on all of the fans in a cooler by 50% (with a 15 dB decrease) rather than shutting down half of the fans (only a 3 dB reduction.)

These systems have the additional advantage in that they may use less power than a single or dual speed system, and could actually end up paying for themselves in long-term power savings.

6.4 Turbine Exhaust System

Often, the ductwork running from the turbine exhaust to the exhaust silencer inlet can be a significant low-frequency noise source. Exhaust expansion joints and other seams in this ductwork are one weak point, but another is the turbine exhaust noise that radiates from the large flat sheet metal walls of the ductwork. **Table 6-1** shows the required turbine exhaust silencer performance for each noise control treatment case along with a sound level target for the entire exhaust system at 400 feet from the base of the stack. These targets include noise radiated from the top of the exhaust stack along with all noise radiated by the various exhaust system components, including expansion joints, duct sections, duct joints, and the exhaust silencer. This target should be included in the exhaust system specification for the chosen noise control treatment Case 1, 2, or 3.

Table 6-1: Exhaust System Insertion Loss (IL) and Sound Pressure Level (SPL) Requirements

Case	Type	IL or Linear SPL at 400'									
		31.5	63	125	250	500	1000	2000	4000	8000	dB(A)
Case 1	IL	8	13	20	31	37	37	35	25	15	
	SPL at 400'	69	65	54	43	42	39	34	32	20	46
Case 2	IL	8	20	26	34	44	44	38	27	15	
	SPL at 400'	69	58	48	40	35	32	31	30	20	41
Case 3	IL	10	23	30	38	48	48	42	29	15	
	SPL at 400'	67	55	44	36	31	28	27	28	20	37

6.5 Turbine Intake System

Similarly, turbine intake noise can radiate from the section of ductwork extending from the turbine intake to the intake silencer. If possible, the expansion joint between the intake silencer and this ductwork should be located inside the compressor building. If this is not possible, it may be necessary to partially enclose the expansion joint in an overlapping sheet metal shield.

Thank you for the opportunity to be of service. Please call if you have any questions or comments.

Sincerely,
HFP ACOUSTICAL CONSULTANTS INC.

David M. Jones, P.E.
Senior Project Engineer

Attachments: Tables 5, 5-1, 5-2, and 5-3.

Table 5: Noise Control Treatments Required for Cases 1, 2, and 3

Case 1: Base Noise Control Treatments

		TL, NR, or IL								
	Type	31.5	63	125	250	500	1000	2000	4000	8000
Building Wall and Roof	TL	6	8	12	18	22	25	30	35	35
Building Vent Intake/Exh Silencer	IL	2	6	12	16	22	28	30	28	16
Building Roll-up Door	TL	2	7	12	17	18	19	22	30	35
Turbine Exh Silencer	IL	8	13	20	31	37	37	35	25	15
Turbine Intake Silencer/Filter	IL	2	4	5	9	18	41	46	48	40
Suct: Pipe Lagging/Blanket Treatment	NR	0	0	1	2	8	16	18	20	20
Disch: Pipe Lagging/Blanket Treatment	NR	0	0	1	2	8	16	18	20	20
Specified PWLs	dBA	31.5	63	125	250	500	1000	2000	4000	8000
Gas Aftercooler	97	107	107	101	97	93	91	87	85	83
Lube Oil Cooler	97	103	101	98	95	93	91	89	88	83

Case 2: Three dB Reduction Noise Control Treatments

		TL, NR, or IL								
	Type	31.5	63	125	250	500	1000	2000	4000	8000
Building Wall and Roof Perf.	TL	6	8	12	**23**	**29**	**35**	**44**	**42**	35
Building Vent Intake/Exh Silencer	IL	2	6	12	16	22	28	30	28	16
Building Roll-up Door	TL	2	7	12	**18**	**20**	**23**	**30**	**38**	**41**
Turbine Exh Silencer	IL	8	**20**	**26**	**34**	**44**	**44**	**38**	**27**	15
Turbine Intake Silencer/Filter	IL	2	4	5	9	18	41	**52**	**51**	40
Suct. Pipe Lagging/Blanket Treatment	NR	0	0	1	2	8	16	18	20	20
Disch. Pipe Lagging/Blanket Treatment	NR	0	0	1	**6**	**16**	**24**	**28**	**30**	20
Specified PWLs	dBA	31.5	63	125	250	500	1000	2000	4000	8000
Gas Aftercooler	96	107	107	101	97	93	91	**86**	85	83
Lube Oil Cooler	97	103	101	98	95	93	91	89	88	83

Case 3: Six dB Reduction Noise Control Treatments

		TL, NR, or IL								
	Type	31.5	63	125	250	500	1000	2000	4000	8000
Building Wall and Roof Perf.	TL	6	8	12	**25**	**31**	**37**	**46**	**42**	35
Building Vent Intake/Exh Silencer	IL	2	6	12	16	22	28	30	28	16
Building Roll-up Door	TL	2	7	12	**18**	**20**	**23**	**30**	**38**	**41**
Turbine Exh Silencer	IL	**10**	**23**	**30**	**38**	**48**	**48**	**42**	**29**	15
Turbine Intake Silencer/Filter	IL	2	4	5	9	18	**43**	**52**	**51**	40
Suct. Pipe Lagging/Blanket Treatment	NR	0	0	1	2	8	16	18	20	20
Disch. Pipe Lagging/Blanket Treatment	NR	0	0	1	**6**	**16**	**24**	**38**	**30**	20
Specified PWLs	dBA	31.5	63	125	250	500	1000	2000	4000	8000
Gas Aftercooler	91	107	107	**98**	**91**	**83**	**80**	**79**	85	83
Lube Oil Cooler	94	103	101	98	95	**90**	**85**	**84**	88	83

Table 5-1: Model Results, Case 1

	Total	A-weighted Sound Level at Octave Center Frequency									Total
	dB(A)	31.5	63	125	250	500	1000	2000	4000	8000	Ldn

Predicted Level at Each NSA (gray indicates higher than the Illinois regulation)

NSA 1	**47**	18	30	34	36	39	41	44	32	10	**54**
NSA 2	**47**	25	34	34	36	39	41	43	33	8	**54**
NSA 3	**48**	26	35	34	36	39	41	44	34	11	**54**
NSA 4	**48**	27	37	36	36	39	41	43	35	16	**54**

Illinois State Octave Band Limits, A-weighted Sound Level at Each Octave
Industrial to Residential

		29	41	46	45	44	41	37	33	31

Reduction from Case 1

1	**0**	0	0	0	0	0	0	0	0	0
2	**0**	0	0	0	0	0	0	0	0	0
3	**0**	0	0	0	0	0	0	0	0	0
4	**0**	0	0	0	0	0	0	0	0	0

Increase over Existing, Day

NSA 1	**6**	5	7	5	5	5	5	8	2	0
NSA 2	**3**	9	7	4	2	2	2	10	4	0
NSA 3	**5**	7	9	5	3	4	4	6	3	0
NSA 4	**4**	9	10	6	3	4	3	6	4	0

Increase over Existing, Night

NSA 1	**14**	18	14	17	18	15	13	17	10	1
NSA 2	**13**	21	19	11	11	11	12	17	11	1
NSA 3	**14**	27	24	15	13	11	11	17	12	1
NSA 4	**15**	25	24	19	16	13	12	16	11	2

Increase over Existing, 24-hour Ldn

NSA 1	**11**
NSA 2	**8**
NSA 3	**10**
NSA 4	**10**

Table 5-2: Model Results, Case 2

	Total dB(A)	31.5	63	125	250	500	1000	2000	4000	8000	Total Ldn
		A-weighted Sound Level at Octave Center Frequency									

Predicted Level at Each NSA

	Total dB(A)	31.5	63	125	250	500	1000	2000	4000	8000	Total Ldn
NSA 1	**43**	19	27	31	34	36	37	36	30	10	**49**
NSA 2	**43**	25	29	30	33	36	37	36	30	8	**49**
NSA 3	**43**	26	29	30	33	36	38	37	31	11	**49**
NSA 4	**43**	28	30	31	33	35	36	36	33	16	**49**

Illinois State Octave Band Limits, A-weighted Sound Level at Each Octave
Industrial to Residential

		29	41	46	45	44	41	37	33	31

Reduction from Base Case

1	**-4**	0	-3	-3	-2	-3	-3	-7	-3	0
2	**-4**	0	-6	-4	-2	-3	-3	-7	-3	0
3	**-5**	0	-6	-4	-3	-4	-3	-7	-2	0
4	**-5**	0	-6	-4	-3	-4	-5	-7	-2	0

Increase over Existing, Day

NSA 1	**3**	5	5	3	3	3	3	3	1	0
NSA 2	**1**	9	3	2	1	1	1	4	3	0
NSA 3	**2**	7	4	3	2	2	2	2	2	0
NSA 4	**2**	9	5	3	2	2	1	2	2	0

Increase over Existing, Night

NSA 1	**10**	18	11	14	16	12	10	10	8	1
NSA 2	**9**	22	13	8	9	8	9	10	9	1
NSA 3	**10**	28	18	11	10	8	8	10	10	1
NSA 4	**10**	25	18	15	13	9	8	9	9	2

Increase over Existing, 24-hour Ldn

NSA 1	**7**
NSA 2	**5**
NSA 3	**6**
NSA 4	**6**

Table 5-3: Model Results, Case 3

	Total	A-weighted Sound Level at Octave Center Frequency									Total
	dB(A)	31.5	63	125	250	500	1000	2000	4000	8000	Ldn
Predicted Level at Each NSA											
NSA 1	**39**	17	26	29	31	31	31	31	30	10	**45**
NSA 2	**39**	23	27	28	31	32	32	33	30	8	**46**
NSA 3	**40**	24	27	28	31	32	33	34	31	11	**46**
NSA 4	**40**	26	28	29	31	32	32	33	32	16	**46**
Illinois State Octave Band Limits, A-weighted Sound Level at Each Octave Industrial to Residential											
		29	41	46	45	44	41	37	33	31	
Reduction from Base Case											
1	**-9**	-2	-4	-5	-5	-8	-9	-12	-3	0	
2	**-8**	-2	-8	-6	-5	-7	-8	-11	-3	0	
3	**-8**	-2	-9	-6	-5	-7	-8	-10	-3	0	
4	**-8**	-2	-9	-7	-5	-8	-9	-10	-3	0	
Increase over Existing, Day											
NSA 1	**1**	4	4	2	2	1	1	1	1	0	
NSA 2	**1**	7	2	1	1	1	0	2	2	0	
NSA 3	**1**	6	3	2	1	1	1	1	2	0	
NSA 4	**1**	7	3	2	1	1	1	1	2	0	
Increase over Existing, Night											
NSA 1	**7**	17	11	12	13	7	5	6	7	1	
NSA 2	**7**	20	11	6	7	5	5	7	8	1	
NSA 3	**7**	26	16	9	8	5	5	8	10	1	
NSA 4	**8**	23	15	12	11	6	5	7	9	2	
Increase over Existing, 24-hour Ldn											
NSA 1	**4**										
NSA 2	**3**										
NSA 3	**4**										
NSA 4	**4**										