Coarse Noise Evaluation

CO_2 Capture Facility

Kårstø, Norway

Rev.	Date	Reason for Revision	By	Check	App	App	
1	15 DEC 08	Client comments incorporated S-0175	HO				
0	19 NOV. 08	Client comments incorporated	HO	BTR	BTR	AJG	

Bechtel Overseas Corporation

Job No. 25474

Document No. 25474 - 000 - U0Y - 0000 - 00004

Rev. 1

GASSNOVA

Project No. - Originator - Disc Code - Doc Type - Serial No.

10112936 - PB - S - HSE - 0012

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Coarse Noise Evaluation

1.0 INTRODUCTION

This document describes the evaluations conducted and measures proposed to limit the off-site and on-site noise emissions.

2.0 PROJECT NOISE REQUIREMENTS

The environmental noise emission limits from the CCP is an overall sound power level of 113 dBA, and a sound pressure level of 40 dBA at night time (2200 to 0600) at the nearest residential property. (Exhibit E8.1 - HSE Requirements)

The distance from the north-east corner of the CCP property to the nearest residence toward the north-east is approximately 700 meters. (Fichtner Query Answer No.: 10112936-A-FIPB-B-0009)

The maximum permitted noise exposure during an 8 hour period is 85dBA (Leq) shall be considered with respect to occupational health and safety. The noise exposure limit refers to the noise reaching the human ear, i.e. inside any hearing protection.

3.0 MAJOR NOISE SOURCES

The flue gas from the GTCC plant is routed from the bottom of the HRSG stack through new dampers, new flue gas duct work, inlet gas blowers and absorber towers. The in-duct noise generated by the blowers (K-101 and K-201) and in-duct noise from the outlet of the HRSG will both contribute to the overall acoustic energy in the flue gas duct system and the associated break-out noise from the duct work.

Based on information provided in Exhibit E0 – Design Basis, the expected frequency-dependent sound power levels from the outlet of the HRSG are:

	HRSG Outlet Sound Power Levels in Octave Band Center Frequencies, Hz									Overall, dBA
	31.5	63	125	250	500	1000	2000	4000	8000	
L_{WA}	81	98	106	114	124	122	115	104	89	127
L_W	120	124	122	123	127	122	114	103	90	127

The expected uncertainty is +/- 5 dB for all octave bands and +/- 3 dB for the overall A-weighted sound power level.

L_{WA} and L_W are the A-weighted and linear (un-weighted) octave band sound power levels. Reference power of 1×10^{-12} W.

Based on preliminary vendor data for the gas blowers (K-101 and K-102), the following frequency specific in-duct octave band sound power levels and fan casing radiated sound pressure levels at 1 meter were considered in the coarse noise evaluation:

	Inlet Gas Blower Gas Blower Induct Sound Power Levels in Octave Band Center Frequencies, Hz									Overall, dBA
	31.5	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	
L_{WA}	93	106	121	133	135	132	133	123	114	140
L_W	132	132	137	142	138	132	132	122	115	140
Uncertainties or measurement tolerances were not included in the octave band sound power levels. The expected uncertainty is +/- 5 dB for all octave bands. L_{WA} and L_W are the A-weighted and linear (un-weighted) octave band sound power levels. Reference power of 1×10^{-12} W.										

	Inlet Gas Blower Gas Blower Casing Sound Pressure Levels at 1 meter in Octave Band Center Frequencies, Hz									Overall, dBA
	31.5	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	
L_{pA}	57	70	80	92	91	86	87	76	67	96
L_p	96	96	96	101	94	86	86	75	68	96
Uncertainties or measurement tolerances were not included in the octave band sound power levels. The expected uncertainty is +/- 5 dB for all octave bands. L_{pA} and L_p are the A-weighted and linear (un-weighted) octave band sound pressure levels. Reference sound pressure of 2×10^{-5} Pa.										

In addition to noise emissions from the flue gas duct work, the in-duct noise from the blowers and HRSG outlet will also radiate from the absorber shells. The inherent design of the flue gas absorber (MV-101 and MV-102) will provide some degree of attenuation of the flow-through noise before the noise exits the absorbers stack.

In addition to the noise associated with the blowers and HRSG outlet noise entering the new flue gas duct work, other major noise sources considered in the coarse noise assessment are the CO2 compressors, building ventilation systems and the seawater pumps.

4.0 NOISE MITIGATION

The CCC plant's overall allowable sound power level is 113dBA. A total sound power level of 110dBA was considered for all major noise sources, which provides a design margin and allowance for multiple sources not included in the coarse assessment. Assuming equal energy contribution from each of the listed major noise sources below, the allowance from each individual major noise source is:

$$113\text{dBA} - 10 \cdot \log_{10}(N),\ N=\text{number of major noise sources}$$

With twelve major noise sources for continuous operation, the allowable sound power level per source is approximately 99dBA.

- Flue Gas Duct
- Flue gas blower (MA-101) building walls and roof
- Flue gas blower (MA-101) building ventilation system
- Flue gas blower (MA-102) building walls and roof
- Flue gas blower (MA-102) building ventilation system
- Absorber (MV-101) shell breakout
- Absorber (MV-101) stack exit
- Absorber (MV-102) shell breakout
- Absorber (MV-102) stack exit
- Compressor building walls/roof
- Compressor building ventilation system
- Seawater pumps (MP-115A/B)

Major Noise Sources operating infrequently:

- Emergency Diesel Generator
- Auxiliary Boiler

Flue Gas Duct Work

With approximately 4000m² of radiating surface area from the flue gas duct, and a design sound power level of 99dBA, the corresponding design sound intensity level at 1 meter from the duct work is 62dBA.

The radiated acoustic energy from the duct work is influenced by the internal acoustic energy, acoustic energy propagation from the HRSG outlet and blowers upstream and downstream in the duct, sound transmission losses of duct wall and lagging system, which is influenced by the thickness of the flue gas duct work, duct stiffness, design of lagging system etc.

Considering an internal sound power level of ~127-140dBA, the radiating surface area of the duct work, and sound attenuation from the duct wall; an acoustical lagging system is required on the exterior of the flue gas duct system in order to reduce the sound intensity to 62dBA at 1 meter from the duct wall. The low corresponding sound pressure levels from the flue gas duct work will not pose a problem from an occupational health and safety perspective.

Blowers

The casing radiated noise from the flue gas blowers, which without noise attenuation is 96dBA at 1 meter from the casing under free field condition. Each blower is housed inside a building. To minimize sound exposure for personnel working inside the blower building, the blower casing shall be installed with an acoustical lagging system to reduce the casing radiated noise to 80-85dBA at 1 meter from the casing. To minimize the interior sound pressure level and reverberation effect, the building walls shall be designed with perforated liner panels with a NRC rating of 0.80 or better.

As a preliminary assessment of the building ventilation system, roof exhaust fans and intake louvers were assumed in the analysis. The building ventilation fans shall be low noise (L_{WA} = 75dBA), and the sound power levels below were assumed for the building ventilation fans (GB-420-30).

	Blower Building Ventilation Fan Sound Power Levels in Octave Band Center Frequencies, Hz								
OBCF, Hz	**31.5**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Lw, dB	-	89	87	78	71	67	63	57	51

The interior noise level, the total open area requirement for intake louvers and the louver sound transmission loss will dictate the overall flow-through sound power level from inside the building to the outside. With the environmental far-field noise being critical toward the north-east, the location of fans, louvers and doors should to the greatest extend be located on west and south facing walls.

The following sound transmission losses were assumed for the building ventilation louvers (Ruskin ACL845):

	Blower Building's Acoustic Louver Sound Transmission Losses in Octave Band Center Frequencies, Hz								
	31.5	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
TLs, dB	-	-	11	6	10	16	17	15	15

The expected average interior sound pressure level in the blower buildings will be 85-90dBA and hearing protection signs should be posted outside the building.

The sound transmission losses of the blower building's wall and roof system will mitigate the noise from the interior of the building to the exterior. The following sound transmission losses were assumed for the wall and roof system:

	Blower Building's Wall/Roof Sound Transmission Losses in Octave Band Center Frequencies, Hz								
	31.5	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
TLs, dB	10	14	16	27	35	43	49	52	52

Absorbers

Noise associated with the absorbers (MV-101 & MV-102) can be divided into shell radiated acoustic energy and noise exiting the absorber stack exit.

The induct noise from the flue gas blowers and HRSG outlet noise propagates downstream in the flue gas duct work and enters the absorbers. The radiated acoustic energy from the absorber shell is mitigated by the absorber shell and insulation.

The radiated acoustic energy from the absorber is influenced by the internal acoustic energy, sound transmission losses of shell and lagging system, which are influenced by the thickness of the absorber shell, and the design of lagging system.

With a preliminary radiating surface area of 1600m^2 from each absorber, and a design sound power level of 99dBA, the corresponding design sound intensity level

at 1 meter from the absorber shell is 66dBA. The low corresponding sound pressure levels from the absorber structure will not pose a problem from an occupational health and safety perspective.

The absorber stack exit noise level is a function of the inherent noise attenuation properties of the absorber internals, acoustic energy entering the absorber, and noise attenuation provided by absorber stack silencer. Each absorber stack exit shall meet an overall sound power level of 99dBA. The sound power level as determined per ISO-10494, and is inclusive of a directivity correction. The sound pressure level measured in the horizontal plane of the exit plane and at 1 meter from the absorber stack exit shall be less than 85dBA.

CO2 Compressors

Casing, discharge and suction pipe radiated noise from the CO2 compressors should be mitigated for personnel protection. The compressors are housed in a building, and to minimize sound exposure for personnel working inside the compressor building, the compressor noise should to reduced to 80-85dBA at 1 meter from the casing and piping. To further minimize the interior sound pressure levels and reverberation effects, the building walls shall be designed with perforated liner panels with a NRC rating of 0.80 or better.

As a preliminary assessment of the building ventilation system, roof exhaust fans and intake louvers were assumed in the analysis. The building ventilation fans shall be low noise (L_{WA} = 75dBA), and the sound power levels below were assumed for the building ventilation fans (GB-420-30).

	Compressor Building Ventilation Fan Sound Power Levels in Octave Band Center Frequencies, Hz								
OBCF, Hz	**31.5**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Lw, dB		89	87	78	71	67	63	57	51

The interior noise level, the total open area requirement for intake louvers and the louver sound transmission loss will dictate the overall flow-through sound power level from inside the building to the outside. With the environmental far-field noise being critical toward the north-east, the location of fans, louvers and doors should to the greatest extend be located on west and south facing walls.

The following sound transmission losses were assumed for the building ventilation louvers (Ruskin ACL845):

	Compressor Building's Acoustic Louver Sound Transmission Losses in Octave Band Center Frequencies, Hz

	31.5	63	125	250	500	1000	2000	4000	8000
TLs, dB	-	-	11	6	10	16	17	15	15

The expected average interior sound pressure level in the compressor buildings will be 85-90dBA and hearing protection signs should be posted outside the building.

The sound transmission losses of the blower building's wall and roof system will mitigate the noise from the interior of the building to the exterior. The following sound transmission losses were assumed for the wall and roof system:

	Compressor Building's Wall/Roof Sound Transmission Losses in Octave Band Center Frequencies, Hz								
	31.5	63	125	250	500	1000	2000	4000	8000
TLs, dB	10	14	16	27	35	43	49	52	52

Seawater Pump

Two (100%) vertical seawater pumps are located in a concrete pit, which will provide some shielding of the pump/motor noise from a far-field noise perspective. Depending on the exact height of the pump/motor assembly relative to the elevation of the pump pit walls, the barrier effect achieved toward the north-east residence will vary. The pump motors under load shall be specified to meet a near-field sound pressure level of 80dBA at 1 meter from the motor casing. With two pumps/motor operating simultaneously; the average near-field sound pressure level around and between the two pumps is expected to be at 85dBA.

Electrical Building, Battery Room, Workshop Area, and Stores Area Ventilation Fans

In the preliminary assessment of the Electrical building, Battery room, Workshop area and Stores area, the building ventilation fans shall be low noise (L_{WA} = 75dBA), and the sound power levels below were assumed for the building ventilation fans (GB-420-30).

	Compressor Building Ventilation Fan Sound Power Levels in Octave Band Center Frequencies, Hz								
OBCF, Hz	31.5	63	125	250	500	1000	2000	4000	8000
Lw, dB	-	89	87	78	71	67	63	57	51