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ENVIRONMENTAL NOISE NEED NOT HINDER GEOTHERMAL POWER DEVELOPMENT

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ABSTRACT

Environmental noise issues have hindered some geothermal power developments located near residents by delaying necessary regulatory approvals. However, with full use of demonstrated noise control technology, noise can be reduced to levels acceptable to most quiet rural communities at a distance of about 1000 feet. Thus, it may be feasible to drill closer to residences than is often presumed.

INTRODUCTION

The purpose of this paper is to show that geothermal steam power can be developed rather close to noise sensitive land uses, provided that available noise control technology is fully utilized. This conclusion was developed as follows: First, noise levels were identified that would be acceptable to a quiet rural community using the "CNR" methods in Reference 1. These methods are based on the use of octave band noise spectra rather than more familiar A-weighted sound levels. This makes the calculations more complex, but the increased accuracy has gained this method acceptance in the electric power industry.

The second step was to estimate at several distances noise levels for geothermal noise sources, based on file data of best demonstrated noise control technology. That is, these methods have been used in geothermal or other industries.

The third step was to compare the noise level estimates to the criteria. Where the noise level estimates in each octave band are at or below the criteria for a given distance, then no adverse community reaction would be anticipated, and no valid complaints of noise expected.

NOISE CRITERIA

The CNR noise criteria method is described in detail in Reference 1. For purposes here, the method is the best known for predicting the likelihood of noise complaints due to industrial noise.(2) It takes into account background noise levels, previous industrial noise exposure, the time of day, duration, and character of the noise, as well as how good relations are between the geothermal developer and his neighbors. The bottom line of Table 1 shows the allowable noise source levels considered acceptable. The remainder of Table 1 shows allowable noise source levels for greater distances.

In calculating noise transmission for Table 1, we conservatively assumed worst case conditions--that is, what would be expected with an atmospheric inversion layer. The assumed temperature was 59^{o}F and the humidity 70 percent.

We presumed that community relations are neither good nor bad. This assumption probably requires the developer to take advantage of the EIR process to show that the project plan minimizes noise impacts. Examples are locating drill sites and access roads as far from residences as possible and preferably behind ridges. Another example is to use as few drill sites as is feasible so that fewer people are noise-impacted. A third is to plan the drill site so that noise is projected away from residences. An often overlooked possibility, communicating factually about the project with the public, may help build project support. One savy developer spoke at a local service club meeting, apparently with significant benefit.

According to the CNR criteria, with poor community relations the residents would be approximately 5-10dB more sensitive to noise. Thus is shown the advisability of taking the above steps.

The background noise level assumed is equivalent to that in a very quiet rural community at night, typically in the mid 20 dBA range. For reference, this is similar to quieter areas near The Geysers, California.

Based on our geothermal experience, the criteria shown on Table 1 are conservative. That is, the community would accept 0-5dBA more noise than is assumed in this paper without complaints.

TABLE 1: OCTAVE BAND NOISE SOURCE LEVELS, MEASURED AT 100 FEET, THAT WOULD BE ACCEPTABLE TO MOST QUIET RURAL COMMUNITIES AT SPECIFIED DISTANCES AT NIGHT. (EQUIVALENT TO 38 dBA IN THE COMMUNITY)

DISTANCE FROM NOISE SOURCE TO COMMUNITY	FREQUENCY								
	31.5Hz	63	125	250	500	1000	2000	4000	8000
4000 FEET	96dB	86	79	72	70	69	71	86	107
2000 FEET	90	80	72	66	62	60	58	65	74
1000 FEET	84	74	66	59	55	52	50	51	54
500 FEET	78	68	62	52	49	45	52	41	41
100 FEET*	63	53	45	38	34	30	26	23	20

*FOR DAYTIME-ONLY NOISES OF SEVERAL DAY'S DURATION, ADD 10 dB, SUCH AS FOR WELL TESTING.

TABLE 2: OCTAVE BAND AND A-WEIGHTED GEOTHERMAL NOISE SOURCE LEVELS FOR STANDARD SILENCING, NORMALIZED TO 100 FOOT MEASUREMENT DISTANCE.

		FREQUENCY									
	dBA	31.5	63	125	250	500	1000	2000	4000	8000
1. 1-1/2 inch open valve, measured downstream, approx. 425 psig	126dBA	-	-	92	102	106	119	120	120	117
2. 6 inch open valve measured downstream, approx. 150 psig	131	-	103	111	110	118	125	125	125	120
3. Drilling in Mud	75-87	82-90	82-86	83-89	70-88	70-86	69-82	66-75	56-71	-
4. Maximum noise of pipe impacts in rig during roundtripping	87	-	-	-	74	84	87	85	71	-
5. Steady noise of two or four air compressors	83-86	88-91	88-91	87-90	79-81	70-73	70-73	67-70	65-68	63-68
6. Steady noise of steam venting into high efficiency drilling muffler w/ water injections, 210 klb/hr	81	89	88	80	73	70	67	66	61	50
7. Same, but for typical muffler at approx. 160 klb/hr, well testing	101	90	91	89	92	89	91	94	95	95
8. Wooden forced draft cooling towers, for 110-135 MW Power Plant at the Geysers, in direction of maximum noise	84	83	86	86	84	79	78	75	73	65

NOISE SOURCE ASSUMPTIONS

Two degrees of noise control are considered for each geothermal development activity. The first is "standard practice", such as is in general use. The second is with the best demonstrated or known, practical technology. Only the major noise sources are considered in this paper. Minor noise sources, such as 100HP generators, are not of concern here, because it is widely known that existing units can be quieted to the degree necessary.

In this report, we will not discuss construction activities or traffic noise. Suffice it to say that the noise impact from most of these sources can be reduced, possibly at some loss in efficiency, provided there is sufficient economic incentive.

EXPLORATORY AND DEVELOPMENTAL DRILLING

In drilling with "mud", the standard noise control is for all engines to have mufflers so that exhaust noise is not prominent. For the silenced operation, it is presumed that better mufflers are in use, that the engines are enclosed or behind barriers, that radiator cooling air openings do not provide excessive noise leaks, that a "winterization" kit is in use, and that "roundtripping" and unnecessary pipe impacts are avoided at night. Small noise barriers, or other means, may be in use to minimize hoist brake squeal. These measures reduce the drilling engine and hoist brake noise by about 15 dB. For the pipe impacts, by slower handling the noise can be reduced by at least 5 dB, except possibly during roundtripping. The standard and reduced noise source spectra are shown on Tables 2 and 3.

DRILLING WITH AIR AND IN STEAM

The dominant noise sources are large air compressors, compressed air releases, and steam venting. The air compressors are normally equipped with a modest sized muffler and no other exhaust noise controls. In this paper, we assumed that at least 20 dB of noise control can be obtained using properly designed engine enclosures and better mufflers.

Compressed air releases may occur when the drill pipe is disconnected. In this paper, we assumed that the drill pipe is always depressurized through an effective muffler. This renders the compressed air releases inaudible in the presence of other noise sources.

For the steam releases, the standard noise control is a cyclonic muffler-separator equipped with an effective water injection system. Also, the inlet piping is properly insulated. For the silenced steam releases, noise barriers, a quieter muffler inlet and better water injection are used. In this paper, we presume that, in combination, these reduce the noise by an additional 10 dB.

WELL TESTING

Some developers have demonstrated that they can flush out and flow test wells through the same muffler as is used in drilling. Sound levels would typically be 10 dB higher than those during drilling, for both the standard and specially silenced mufflers. However, testing normally can be scheduled as a daytime-only activity, so that the noise impact is no greater than that of the steam releases during drilling.

TABLE 3: OCTAVE BAND AND A-WEIGHTED GEOTHERMAL NOISE SOURCE LEVELS, SPECIALLY SILENCED WITH KNOWN TECHNOLOGY, NORMALIZED TO 100 FOOT MEASUREMENT DISTANCE.

			FREQUENCY								
		dBA	31.5	63	125	250	500	1000	2000	4000	8000
1.	Drilling in Mud	60	67	67	68	55	55	54	51	41	-
2.	Maximum noise of pipe impacts in rig during roundtripping	82	-	-	-	69	79	82	80	66	-
3.	Steady noise of two or four air compressors	63-66	68-71	68-71	67-70	59-61	50-53	50-53	47-50	45-48	43-48
4.	Steady noise of steam venting into high efficiency drilling muffler w/ water injections, 210 klb/hr	71	79	78	70	63	60	57	56	51	40
5.	Wooden forced draft cooling towers, for 110-135 MW Power Plant at the Geysers, in direction of maximum noise	79	78	81	81	79	74	73	70	68	60

PRODUCTION NOISE

The dominant noises during steam production and power generation are control valve noise, noise from separator drains and driplegs when vented, and master valve replacements. Our experience is that with valve noise control techniques and careful pipeline location, valve noise is not environmentally significant.

Separator drains and other steam releases can be extremely noisy and are partly responsible for the noisy reputation earned by early geothermal developments. Table 2 shows noise levels from 1-1/2 inch and 6 inch valves being opened to the atmosphere. These noise levels are so high that they are unacceptable, by comparison of Tables 1 and 2, even at the largest distance shown. For the silenced case, all driplegs, separator drains and miscellaneous steam releases are silenced to insignificance--possibly using small rock mufflers or other mufflers.

For master valve replacements, when feasible, it is presumed that the well bore is plugged during valve replacement, so that any steam releases are of short duration and small, and resulting noise is slight.(3) Valves are replaced so seldomly that a community may temporarily tolerate even high noise levels, if need be.

POWER PLANT

For a carefully designed geothermal plant, the mechanical draft cooling towers are the only noise source for which there is no readily available noise control technology that is highly effective, yet economical. In this paper, we assume that cooling tower noise can be reduced by approximately 6 dB, mostly by using special fans and possibly adding additional cells. An additional 4-6 dB of noise reduction is possible in some cases, but is not assumed for this paper. Also, yet more noise control is possible, but at higher cost.

CONCLUSIONS

Presuming a clear line of sight between the geothermal development and residences, the following conclusions are valid. First, the standard practice noise levels (Table 2) are just above those acceptable at 4000 feet (Table 1) for drilling with mud, air, or in steam, and for the cooling tower. Thus, limited noise complaints would be expected, which is consistent with experience. Noise shielding by terrain, forests, equipment or a lip of the pad would be necessary to eliminate the complaints and may allow a shorter distance.

For the silenced drilling noise source levels shown on Table 3, the noise limits for 1000 feet are just exceeded for 125 and 1000 Hertz. Thus the minimum distance for no complaints is a bit above 1000 feet. However, by shielding some noise sources with equipment and by some use of noise barriers, a margin of safety could be achieved, even at 1000 feet. This would seem wise given Murphy's Law.

The cooling tower noise would be above the criteria, at 4000 feet, and would be the dominant power plant noise source. Thus, the cooling tower noise would be the major problem in locating the power plant close to the "very quiet" community. Fortunately, in actual practice, it is usually possible to reduce noise by using building and terrain shielding, noise source directivity, and possibly other methods. Also, the efficient atmospheric sound transmission assumed in this paper is not likely at all sites.

The noise reductions presumed would not be likely by casually muffling and enclosing engines and steam vents, and installing rock mufflers on all pads. Instead, all factors would have to be considered, and the final noise controls methodically designed and installed. Developers and regulators should also realize that the noise reductions would require continuing attention and supervision, and in some cases may have significant hidden costs. Furthermore, at a distance between about 1000 and 2000 feet, many minor nighttime noise sources may require attention, such as hammering, swearing and other activities. Thus, the degree of noise reduction assumed for 1000 feet in this paper should not be offered or required without carefully documented justification.

The "single complaint" noise criteria used in this paper is conservative. While in some cases, adopting this criteria as a project design goal may be prudent, meeting the goal at all times for all noise sources is not realistic or expected. This is why noise ordinances and use permits typically allow higher noise limits for residential, transportation and industrial noise sources - out of practical and economic necessity.

It is believed that the conclusions in this paper would also apply to electrical power from hot water dominated resources, as well as dry steam developments.

REFERENCES

(1) Stevens, K.N., Rosenblith, W. A., and Bolt, R. H., 1955, A Communities Reaction to Noise: Can It Be Forecast:, "Noise Control" magazine, Vol. 1 No. 1.

(2) Edison Electric Institute, 1978, Electric Power Plant Environmental Noise Guide, Volume I.

(3) Personal communication with Mr. Tebow of WKM.