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Administrative Countermeasures in Japan for Infrasound-related Problems

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Abstract:
The paper describes the updated situation in Japan regarding the following infrasound-related issues.
- Occurrences and complaints
- Measurement methods and devices on ISO 7196
- Latest issued-guidelines by the Ministry of the Environment for local governments' countermeasures

Minute changes in pressure occurring in the atmosphere are picked up by the human ear and perceived as sound. This is called auditory perception. There are various causes for these changes in pressure which are transmitted in the atmosphere. Since the way these fluctuations spread resembles the propagation of a wave on the surface of water, the phenomenon is commonly referred to as "sound waves". Some sound waves can be likened to a slow swell, while others are more like tiny ripples. Not all of these waves are heard by humans as sound. The range of human hearing is usually considered to extend from about 20 Hz to 20,000 Hz. The present study concerns itself mainly with very low frequencies under 20 Hz, a range also called "infrasound". When examining the low frequency range with a view to environmental impact, the frequency range from 1 - 80 Hz is usually considered.

In so far as vibrations are being transmitted in the atmosphere, low-frequency noise is no different from other kinds of noise. But the fact that the frequency of such noise is extremely low makes for some peculiarities. Low-frequency noise as an environmental problem usually has two aspects. One is complaints about direct auditory perception of the vibrations as noise, and the other is complaints caused by indirect perception, such as by rattling windows, doors, and other fixtures.

(1) Sources and complaints

Table 1 shows a chronology of low-frequency sound related events and problems

Table 1

Year	Event	Remarks
1883	Observation of pressure wave caused by Krakatau volcano eruption	London, Tokyo Meteorological Observatory
1906	Design proposal for a tasimeter using flame	Shaw, W.N & Dines, W.H.
1908	Observation of infrasound caused by meteor impact in Siberia	
approx. 1910	Determination of enemy gun position by observation of shelling sound	
1913	Study of explosive sound of Mt. Asama eruption	
1921	Development of hot-wire microphone for gun position detection	Tucker, W.S. & Paris, E.T.
1937	Electromagnetic tasimeter developed	Benioff, H. & Gutenberg, B.
1941	Demonstration of principle and experiment for sound source location by shelling sound	Bragg, W.
1952	Analysis of generation mechanism, acoustic energy, and propagation of infrasound	Daniels, F.B.
1956	Observation of explosive sound of Bezymianny volcano eruption	In Russia, England, and at Kushiro
1956	Invention of wind noise reduction pipe for strong winds	Daniels, F.B.
1957	Recording of infrasound during large rocket launch	Kaschak et al
1958	Observation of explosive sound of Mt. Asama eruption	Recorded by tasimeters at various locations in Japan
1961	Development of measurement system for sonic boom caused by supersonic aircraft	Taniguchi, H. H.
1962	Review of infrasound caused by sea waves	Cook, R. K.
1962	Measurement of infrasound caused by magnetic storms and tornadoes	Cook, R. K.
1963	Estimation of infrasound absorption factor	Cook, R. K.
1964	Development of Solion microphone	Collins, J.L. et al
1965	Clarification of generation and propagation of earthquake induced infrasound	Cook, R. K.
1966	Demonstration of sensing flame for visual observation of infrasound	Gavreau, V. et al

1966	Development of tasimeter for shelling sound measurement	Gavreau, V. et al
1966	Identification of problems with sonic boom measurement technology	Hilton, D.A. & Newman, J.W.
1967	Development of multi-element sensor array for measurement of infrasound caused by nuclear explosion	Fehr, U.
1969	Measurement of low frequency sound emitted by diesel-type electric power generating plants	Kono et al
1969	Development of piezoelectric low frequency microphone	Tokita, Shimizu
1969	Occurrence of minute vibrations of unknown origin	Jushiyamamura, Ama-gun, Aichi prefecture
1970	Measurement of low frequency sound emitted by large diesel engines using a pressure transducer	Nakano, Ikegami
1970	Development of low frequency microphone using gauge as pressure transducer	Nishiwaki, Mori
1971	Demonstration of measurement system for infrasound	Hood, R.A. & Levebthall, H.G.
1971	Analysis of wind influence on propagation of infrasound emitted by rockets	Balanchandran, N.K. et al
1971	Study of infrasound at Tappan Zee bridge on Hudson river	Donn, L.W. et al
1973	Market introduction of low frequency microphone	RION
1975	Measurement example of infrasound in vicinity of Saturn V	Malecki
1975	Complaints about micro pressure waves produced when Shinkansen trains enter a tunnel	Sanyo Shinkansen
1976	Environment Agency conducts nation-wide survey of low frequency sound	
1976	Suicide because of infrasound problems	Chuo Expressway, Achigawa bridge
1976	Study of low frequency sound and building vibrations caused by road bridges	Shimizu et al
1976	Study of low frequency sound caused by discharge of sand guard dam	Gifu prefecture
1976	Study of low frequency sound and its propagation caused by discharge of dams	Kanazawa et al
1977	Study of secondary sound caused by fixture vibrations due to low frequency sound	Kobayasi Institute of Physical Research
1977	Measurement of acoustic radiation power due to vibration of	Konishi, Aoki

	elevated bridges	
1977	Development of low frequency sound phase-contrast detector	Nishiwaki
1978	Measurement of infrasound in high-rise buildings during rainstorms	Bruel, P.V.
1978	Proposal of a low frequency sound measurement standard (G1, G2 characteristics)	Bruel, P.V.
1980	Observation of explosive sound of Mount St Helens eruption	Registered worldwide
1980	Development of simple measurement system for propagation of low frequency sound	Fukuhara, Okuma
1980	Proposal of G1, G2 characteristics as ISO standard for low frequency sound measurement	Bruel, P.V.
1983	Development of low frequency sound source detector based on acoustic intensity method	RION
1983	Measurement of infrasound produced by wind turbine generator systems	Hubbard, H.H. et al
1984	Observation of infrasound caused by typhoons	Yang, X. & Xie, J.
1984	Study of infrasound generated by experimental wind turbine installation on Miyake island	Inoue et al
1985	Development of low frequency sound source detection system using cross spectrum method	Akamatsu et al
1985	Occurrence of building vibrations caused by discharge of Reno river in Italy	Bragadin, G.L. et al
1986	Recording of infrasound caused by Mt. Mihara eruption using a level recorder	Institute of Noise Control Engineering, Japan
1986	Clarification of nuclear explosion infrasound waveform	Zie, J. & Wang, J.
1986	Observation of infrasound associated with Challenger explosion	Yang, X. et al
1987	Observation of infrasound associated with annular eclipse	Yang, X. & Xie, J.
1991	Proposal for a measurement method of low frequency sound and infrasound	Institute of Noise Control Engineering, Japan, Subcommittee for Low Frequency Sound
1993	Increased complaints about micro pressure waves associated with increased train speed	Sanyo Shinkansen
1995	Infrasound measurement standard ISO 7196 stipulated	

2000	Environment Agency publishes measurement manual for low frequency sound	
2002	Ministry of Environment provides sound pressure level meters for measurement of low frequency sound to municipalities	
2003	Ministry of Environment publishes countermeasure example compendium Guidelines regarding low frequency sound are under consideration	

(2) ISO 7196 measurement method and measurement equipment

The standard defines the various specifications relating to equipment used for measuring low frequency sound. It includes detailed calibration specifications for microphone, voltage amplification, meter indication, and other aspects.

An important point is that the standard defines the frequency weighting characteristics (G characteristics) for measuring and evaluating low frequency sound.

(3) Latest guidelines issued by Ministry of Environment to local authorities

In August 2002, the Ministry of Environment established a "Low Frequency Sound Countermeasure Committee" at the Institute of Noise Control Engineering, Japan. The committee considered topics such as a manual and evaluation guidelines and issued a "Manual for Low Frequency Sound Countermeasures". This document was compiled with the intention of assisting local authorities in dealing with problems related to low frequency sound. It covers basic processes from handling claims to analyzing and solving problems. The manual also outlines methods and points to be considered and provides technical background on relevant issues.

Local administrative personnel in charge of dealing with low frequency sound problems and other environmental complaints are expected to refer to the manual when attempting to find solutions. The manual comes with the proviso that it is to be considered as a reference, not as a strict set of rules. It clearly states that local authorities will have to adapt their countermeasures to the respective conditions.

Because the manual has been prepared using data that were current at the time of compilation, it is to be hoped that feedback from the communities will be evaluated and incorporated in future versions, to improve efficiency and widen the scope of solutions that are covered.

An example of measuring equipment currently used in Japan for low frequency sound level measurements is appended.

RION

G-weighting and 1/3 Octave Real-Time Analysis

NEW! Infrasound Level Meter 1/3 Octave Band Analyzer NA-18

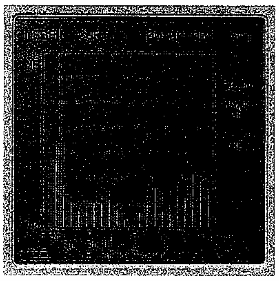
ISO 14001　ISO 9001
CERTIFIED MANAGEMENT SYSTEM JQA ENVIRONMENTAL SYSTEM　CERTIFIED MANAGEMENT SYSTEM JQA QUALITY SYSTEM
JQA-EM0488　JQA-0334

Outline

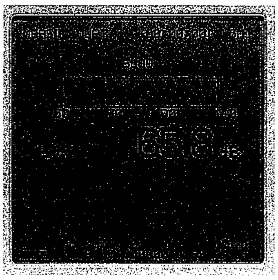
Infrasound Level Meter 1/3 Octave Band Analyzer NA-18

Low-frequency air vibrations including infrasonic noise are sound pressure changes at frequencies that are too low to be directly audible to the human ear. However, such vibrations can cause windows and other parts of buildings to resonate. The vibrations also can have various physiological effects, such as provoking tinnitus (ringing in the ears), headache or discomfort, as well as causing increased pulse or blood pressure. The NA-18 is a low frequency sound level meter designed for use in environmental evaluations aimed at identifying infrasonic noise. It has various specialized features including G-frequency weighting.

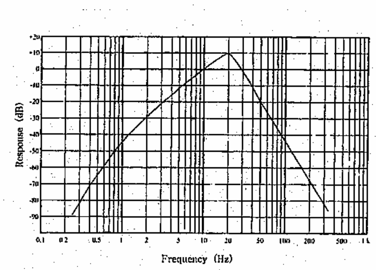
- **G-frequency weighting**
- **1/3 octave real time analyzer**
- **Frequency range extends from 1 to 1000 Hz**
- **Sophisticated digital signal processing**
- **192 × 192 dot LCD with LED backlighting**
- **Integrated memory holds up to 6000 data with auto- store function**



■Graphical display of 1/3 octave analysis



■G-weighting measurement display



■G-weighting shown in ISO 7196, 1995

Specifications

Applicable standards	ISO 7196 : 1995 JIS C 1513 : 1983 Type I IEC 61260 : 1995 Class 1
Measurement functions	G-weighted sound pressure level Real-time 1/3-octave analysis in 1 - 80 Hz range
Processing functions	Instantaneous value L_p Equivalent continuous sound pressure level L_{eq} Maximum sound pressure level L_{max} Waveform peak hold L_{peak}
Measurement time	10 seconds, 1, 5, 10, 15, 30, 60 minutes, Free (manual measurement stop; up to 8 hours)
Microphone	UC-24 (ceramic microphone with integrated preamplifier)
Measurement range	G weighting: 50 - 147 dB (in 110 - 140 dB range overload 3 dB) Flat: 53 - 147 dB (in 110 - 140 dB range overload 3 dB)
Noise floor	G weighting: Less than 40 dB Flat: Less than 48 dB
Level range	
G weighting sound level meter mode (display range 60 dB)	50 - 90 dB (5 ranges, 10-dB step)
Frequency analysis mode (display range 70 dB)	40 - 80 dB (5 ranges, 10-dB step)
Overload characteristics	Display full-scale point +3 dB
Measurement frequency range	1 - 1000 Hz (1/3 octave analysis frequency range 1 - 80 Hz) 0.2 - 1000 Hz (amplifier only)
Frequency weighting	G-weighting (digital) and flat weighting (analog)
RMS detection	Digital true rms detection (digital)
Time constant	Fast (125 ms), Slow (1 s), 10 s, Peakhold
Calibration	Electrical calibration with 250-Hz sine wave signal from built-in oscillator
Memory function	
Manual store	Storing of displayed measurement results in internal memory. Max. 200 data.
Auto store	Continuous storing of measurement results in internal memory. Max. 6000 data.
Level trigger function	Processing starts when preset level is exceeded.
Display	Backlit LCD, 192 × 192 dots G weighting sound pressure level meter display (numeric and bar graph) 1/3 octave analysis display (numeric and bar graph) Level-time indication, Battery warning indication
Inputs and outputs	External power supply input, AC output, DC output, Serial I/O connector, Infrared port
Interface	RS-232-C
Power requirements	Four IEC R14 (size "C") batteries or external AC adapter NC-94
Operation time on batteries	6 hours (alkaline batteries, at 25°C) 2.5 hours (manganese batteries, at 25°C)
Current consumption	360 mA (at 20°C, external power supply input voltage 5 V)
Ambient conditions for operation	−10 to +50°C, 30 to 90% RH (no condensation)
Dimensions and weight	319 × 100 × 50 mm, Approx. 630 g (without batteries)

Supplied accessories

Storage case	× 1	Soft case	× 1
Tripod adapter	× 1	Windscreen	× 1
BNC-to-PIN cable	× 1	Miniature screwdriver	× 1
Size "C" batteries	× 4	Hand strap	× 1
Instruction Manual	× 1	Lithium battery	× 1

Specifications subject to change without notice.

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