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Code for design of noise control of industrial enterprises

工业企业噪声控制设计规范

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Issued on: November 29, 2013 **Implemented on: June 1, 2014**

Issued by: Ministry of Housing and Urban-Rural Development;

General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China.

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Main drafting organization:

Ministry of Housing and Urban-Rural Development of the People's Republic of China

Approved by:

Ministry of Housing and Urban-Rural Development of the People's Republic of China

Date of implementation:

June 1, 2014

China Architecture & Building Press

Beijing 2013

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Foreword

This Code was revised by Beijing Municipal Institute of Labor Protection jointly with organizations concerned on basis of the previous national standard "Specifications for the design of noise control system in industrial enterprises" (GBJ 87-85) according to the requirements of Building Code [2009] No. 88 issued by the Ministry of Housing and Urban-Rural Development - “Notice on printing the development and revision plan of national engineering construction standards from in 2009”.

During the process of revising this Code, the drafting group carried out extensive investigations, carefully summarized the practical experience, made reference to relevant international standards and advanced standards of other countries, widely solicited for opinions, made improvement, reviewed and finalized this Code.

This Code comprises eight clauses. Its main technical contents are: General provisions, Terms, Design limits of noise control of industrial enterprises, Industrial enterprises in the overall design of noise control, Sound insulation design, Muffler design, Sound absorption design, and Vibration isolation design.

The main technical contents revised in this Code are: 1. added the content on limit for impulsive noise; 2. made an appropriate modification on the noise limits for various workplaces; 3. modified the relevant clauses on the noise and vibration control measures.

This Code shall be under management of the Ministry of Housing and Urban-Rural Development. The routine management and the interpretation of specific technical contents shall be performed by Beijing Municipal Institute of Labor Protection. During the process of implementing this Code, the relevant opinions and advices, whenever necessary, can be sent to Beijing Municipal Institute of Labor Protection (Address: No. 55, Taoranting Road, Xicheng District, Beijing, 100054, China).

Main drafting organization of this Code: Beijing Municipal Institute of Labor Protection

The drafting organizations of this Code: Institute of Acoustics, Chinese Academy of Sciences, China Academy of Building Research, China Architecture Design and Research Group, Chinese Research Academy of Environmental Science, National Industrial Standard Rating Station of Building Materials, Beijing Center for Disease Prevention and Control, Beijing Urban Construction Science Technology Promoting Association, North China Institute of Science and Technology, Beijing Greentec Acoustic Engineering

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Code for design of noise control of industrial enterprises

1 General provisions

1.0.1 This Code is formulated with view to preventing the noise hazard of industrial enterprises, guaranteeing the employees' health, ensuring the safety production and normal work, and protecting environment.

1.0.2 This Code is applicable to the noise control design of the construction, renovation, extension and technical transformation engineering of industrial enterprises.

1.0.3 The noise control design of the construction, renovation and extension engineering of industrial enterprises shall be carried out in parallel with the engineering design.

1.0.4 The design of noise control of industrial enterprise shall cover comprehensive analysis on the production process, operating maintenance, noise reduction effect, and technical and economic efficiency.

1.0.5 As for the noise generated during production process and by equipment, control shall be carried out at the sound source at first by replacing the high noise process and equipment with the low noise process and equipment; if it still fails to meet the requirement, the noise control measures such as sound insulation, noise elimination, sound absorption, vibration isolation and integrated control shall be taken.

1.0.6 As for such workshops and workplaces that still fail to meet the design limit of noise control after being taken with corresponding noise control measures, proper personal protective measures shall be taken.

1.0.7 In addition to the requirements stipulated in this Code, the design of noise control of industrial enterprises also shall comply with those in the current relevant standards of the nation.

2 Terms

2.0.1 Workplace

All working places controlled directly or indirectly by the employing unit and serving for occupational activities of laborers.

2.0.2 Impulsive noise

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The sound field where the energy density is uniform and is randomly distributed in all transmission directions.

2.0.13 Sound bridge

The rigid connection between two layers in the double-layer or multi-layer sound insulation structure, by which the sound energy is transmitted in these two layers in the manner of vibration.

2.0.14 Sound lock

A structure with a large number of chambers or corridors being capable of absorbing sound energy, which is used to connect both sides indoors but also achieve very low sound coupling, so as to improve the sound insulation capacity of two compartments.

2.0.15 Muffler

The airflow line with acoustic lining or in special shape, which can effectively reduce the noise in air flow.

2.0.16 Sound absorption

The process that the sound energy is reduced or converted to other types of energy when the sound wave passes through a certain medium or shots onto a certain dielectric surface.

2.0.17 Vibration isolation

The measure using elastic support to reduce the capability of the system to respond to extrinsic motivation. At stable state, vibration isolation is represented by the reciprocal of transmissibility.

2.0.18 Insertion loss

The sound pressure level difference at a certain measurement point before and after inserting the noise control equipment.

3 Design limits of noise control of industrial enterprises

3.0.1 The noise limits of various workplaces of industrial enterprises shall be in accordance with those specified in Table 3.0.1.

Table 3.0.1 -- Noise Limits of Various Workplaces

Workplaces	Noise limits

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planning and industrial layout of the located area, and the site should not be selected at the centralized area of noise-sensitive buildings.

4.2.2 The site of industrial enterprise generating high noise shall be located at the windward side of the wind direction with local perennial minimum frequency in summer of the urban residents centralized area; the site of noise-sensitive industrial enterprise shall be located at the downwind side of the wind direction with local perennial minimum frequency in summer of the surrounding major noise source.

4.2.3 For the noise-sensitive enterprise, its site should not be selected at the high noise environment area and shall be far away from traffic artery, airport and main air route.

4.2.4 For the site selection of industrial enterprises, the natural buffer region shall be utilized.

4.3 General layout design

4.3.1 Under the premise of meeting the process flow requirements, the general layout of industrial enterprises shall meet the following requirements:

1 In combination with the function partition and process partition, the living quarters and administrative office area shall be separated from the production area, and the high noise plant and low noise plant shall be arranged separately. The major noise sources in industrial enterprises should be concentrated relatively and should be far away from the on-site or off-site areas required to be quiet.

2 Tall buildings and structures insensitive to noise and in a direction conducive to sound insulation should be arranged surrounding the major noise sources and production workshops. Warehouses and stock grounds should be arranged between high noise area and low noise area.

3 For the buildings required to be quiet indoors, its orientation arrangement and height shall be conducive to sound insulation.

4.3.2 The elevation layout of industrial enterprises shall insulate noise by using terrain and surface features; the major noise sources should be arranged at low position and the noise-sensitive buildings should be arranged in the sound shadow region of natural barrier.

4.3.3 Under the premise of meeting the requirements of various use functions, the on-site transportation design of industrial enterprises shall meet the following requirements:

1 Main transportation routes on-site should not pass through the

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noise-sensitive area;

2 The living and administrative facilities and other buildings arranged at both sides of transportation route on-site shall be kept with a proper distance from the transportation route.

3 The end type arrangement should be adopted for the roads arranged at noise-sensitive area.

4.3.4 Where the noise design standard cannot be reached still after the measures in Articles 4.3.1 ~ 4.3.3 of this Code are adopted in general layout design of industrial enterprises, the noise control measures shall be taken or the necessary protection distance shall be arranged between all plants and buildings.

4.4 Technology, pipeline design and equipment selection

4.4.1 Under the premise of meeting the production requirements, the process design of industrial enterprises shall meet the following requirements:

1 Impact process shall be reduced;

2 Drop shall be reduced for the block material conveying;

3 The process reducing the discharge high pressure gas to air shall be adopted;

4 The equipment process with mechanized operation and automatic running shall be adopted, and remote monitoring operation should be adopted.

4.4.2 Under the premise of meeting the process requirements, the pipeline design of industrial enterprises shall meet the following requirements:

1 The flow speed in pipeline shall be reduced, the pipe section should be free from sudden change and the forward flow direction should be adopted for pipeline connection;

2 The valves on the pipeline should select the low noise products;

3 The flexible connection shall be adopted for the pipeline and equipment with intense vibration;

4 The rigid connection should not be adopted for the support of pipeline with intense vibration;

5 For the pipeline radiating load noises, it should be arranged underground

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or be taken with proper sound insulation and noise elimination measures.

4.4.3 The equipment with lower noise and less vibration should be selected in the design of industrial enterprises. Selection of major noise source equipment shall be determined comprehensively after collecting and comparing the noise objectives of same type of equipment.

4.4.4 The equipment selection in the design of industrial enterprise shall include the equipment specified for noise control.

4.5 Plant layout

4.5.1 Under the premise of meeting process flow requirements, the high noise equipment should be concentrated relatively and arranged at a corner of workshop. Where it still has visible influence on the workshop environment, proper sound insulation and other control measures shall be taken.

4.5.2 The equipment with intense vibration should not be arranged on the floor slab or platform.

4.5.3 During the equipment layout, the necessary space for installation and maintenance of matched equipment specified for noise control shall be reserved.

5 Sound insulation design

5.1 General requirements

5.1.1 Sound insulation design shall be carried out for the situation controlling the noise within the local space.

5.1.2 For the sound insulation design of sound source, the acoustic enclosure may be adopted or the structure type of sound insulation enclosing shall be adopted at the workshop where sound source is located; for the sound insulation design of noise transmission pathway, the structure type of sound insulation barrier may be adopted; for the sound insulation design of receiver, the structure type of sound insulation room may be adopted. If necessary, the above-mentioned kinds of structure types may also be adopted simultaneously.

5.1.3 In the case of meeting the requirements of operation, maintenance and ventilation and cooling, the acoustic enclosure of corresponding type shall be adopted for the independent

strong noise source in workshop according to the insertion loss of acoustic enclosure. The insertion loss of acoustic enclosure may be selected according to those specified in Table 5.1.3.

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should not be less than 50 mm;

2 The coincidence frequency of sound insulation structure should not present on medium frequency band; as for double-layer structure, the thickness of each layer should not be identical or different rigidity should be adopted or damping should be added;

3 The quantity of sound bridge shall be reduced for the connection between double-layer structures;

4 Porous sound absorption materials should be filled in double-layer structure.

5.3.4 The design and selection of sound proof door/window shall meet the following requirements:

1 Under the premise of meeting the requirements of sound isolation, approved product shall be selected;

2 Sound leakage through gap shall be avoided; the sound insulation performance of door leaf and window sash shall match the tightness of gap treatment;

3 Where the sound isolation requirements cannot be met when single-layer sound proof door is adopted, sound lock with two sound proof doors may be designed; the inner wall surface of sound lock shall possess high sound absorption property; the two doors should be arranged in a staggered way;

4 Where the sound isolation requirements cannot be met when single-layer sound proof window is adopted, double-layer or multiple-layer sound proof windows may be designed;

5 Special sound proof door/window may be designed for special circumstances.

5.3.5 The design of sound insulation room shall meet the following requirements:

1 As for sound insulation room with high requirements on sound isolation, sound insulation structure mainly adopting building materials such as solid brick should be adopted; double-layer structure may be adopted for wall and roof if necessary; sound lock with two sound proof doors and multiple-layer sound proof windows should be adopted for the sound insulation members such as door and window.

2 The combined sound insulation amount of sound insulation room may be calculated according to the following formulae:

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6.1.1 Aerodynamic noises radiated from aerodynamic machinery or noises radiated from heat dissipation holes, air vents and auxiliary holes on envelop enclosure used for sound insulation of noise source shall be carried out with noise elimination design.

6.1.2 If space permits, the installation position of mufflers shall meet the following requirements:

1 Where the air inlet (outlet) of aerodynamic machinery is open, the inlet (outlet) muffler shall be installed at the place near the air inlet (outlet);

2 Where no air inlet (outlet) of aerodynamic machinery is open, the sound insulation of pipeline is poor and the noise of space with pipeline passing through fails to meet the requirement, mufflers shall be installed;

3 Where holes of envelop enclosure for sound insulation of noise source radiate noises, mufflers shall be installed at the place with holes.

6.1.3 Insertion loss of muffler shall be determined according to the design for noise elimination.

6.1.4 Pressure loss caused by mufflers shall be controlled within the permissible range for normal operation of equipment.

6.1.5 Environmental impact caused by regeneration noise generated by air flow of muffler shall not exceed the permissible noise level of the environment.

6.1.6 Air velocity in muffler shall meet the following requirements:

1 Air velocity in muffler of main pipeline of air-conditioning system should not be greater than 10m/s;

2 Air velocity in inlet and outlet mufflers of air blower, compressor and gas turbine should not be greater than 30m/s;

3 Air velocity in inlet and outlet mufflers of internal combustion engine should not be greater than 50m/s;

4 Air velocity in high pressure outlet muffler should not be greater than 60m/s.

6.1.7 Mufflers shall be of stable and durable, and shall meet moisture-proof, fire protection, anticorrosion, high-temperature resistant and oil stain-proof requirements.

6.2 Muffler design procedures and methods

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6.2.1 Noise elimination design shall be carried out according to the following procedures:

1 Determine the sound power level of each octave band of the noise source;

2 Predict sound pressure level and A-weighted sound pressure level of each octave band at the noise control point according to the position of noise source, position of noise control point (one or several), the characteristics of noise transmission approach between them as well as the characteristics of rooms (or characteristics of outdoor environment) where the control points are located;

3 Obtain the super-scale of the sound pressure level (or A-weighted sound pressure level) of each octave band at the control point according to the permissible limiting value of sound pressure level (or A-weighted sound pressure level) of octave band at the noise control points;

4 Determine the insertion loss required by each octave band of muffler according to the super-scale and select the muffler meeting the requirement;

5 Re-conduct the calculation of step 2 to inspect the sound pressure level at the control point according to the insertion loss and air-caused-regeneration noise value of selected muffler, and the sound pressure level at the control point shall meet the requirements of limiting value;

6 Where the selected muffler fails to meet the requirements, adjust the type of muffler according to the super-scale, and repeatedly conduct the calculation of step 2 until meeting the requirements.

6.2.2 The sound power level of 8 octave bands of noise source whose center frequency is 63Hz~8,000Hz shall be provided by the manufacturer of equipment generating noise; where the equipment manufacturer fails to provide, it may be determined by measuring, estimating or looking up materials.

6.2.3 The installation position of muffler shall be selected according to the position radiating noises, noise transmission mode and the provisions of Article 6.1.2 in this Code.

6.2.4 The permissible sound pressure level of each octave band at the noise control point shall be calculated by Formula (5.2.3) in this Code or be selected from those given Table 5.2.3-1 according to noise limits given in Article 3.0.1 of this Code.

6.2.5 The predicted sound pressure level at the noise control point may be calculated according to Formula (5.2.2) in this Code; the insertion loss and

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ineffective high-frequency shall be prevented, and its upper cut-off frequency may be calculated according to following formula:

$$f = 1.85\frac{c}{D} \qquad (6.3.2)$$

where,

f - the upper cut-off frequency;

c - the velocity of sound, 340 m/s may be taken under normal temperature and pressure;

D - the equivalent diameter of muffler channel section, m.

6.3.3 The structural form of dissipative muffler shall be selected in accordance with the following requirements:

1 Where the equivalent diameter is not larger than 300mm, straight pipe muffler may be selected;

2 Where the equivalent diameter is larger than 300mm, sheet type or folded plate type muffler may be selected; the spacing between sheets should be 100mm~200mm, and the flex of damping sheet of folded plate muffler shall meet that sight is impervious, and the bevel should not be greater than 20°;

3 The noise elimination channel may be of sinusoidal wave form, streamline form or rhombic structure form, and its flex angle shall meet that the sight is impervious;

4 Ventilating pipeline system with lower air velocity may adopt labyrinth muffler; chambers of muffler should be 3 pcs~ 5 pcs, and the air velocity in muffler should be less than 5 m/s;

5 For ventilation and air conditioning system, of which the air volume is not large and the wind speed is not high, noise elimination elbow may be selected, and the air velocity in it should not be less than 8m/s.

6.3.4 Where the noise shows obvious low and medium-frequency impulse characteristic, or dissipative sound-absorption materials should not be used in air channel, muffler may be the expanded cabinet type. The design hereof shall meet the following requirements:

1 The noise elimination amount of expanded cabinet muffler may be increases by means of increasing the expansion ratio; the method of changing the length of cabinet is used for regulating the noise elimination frequency characteristics;

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2 When several expanded cabinets are connected in series to increase the noise elimination amount, and the lengths of the cabinets shall not be same;

3 Inner connecting pipes whose lengths respectively equal to 1/2 and 1/4 of the cabinet length shall be inserted into the cabinet; inner connecting pipes should be connected by perforated pipes with the penetration rate not less than 30%;

4 Where the pipe diameter of inner pipeline of expanded cabinet muffler exceeds 400mm, multi-pipe type may be adopted.

6.3.5 Where the noise shows low and medium frequency characteristics, muffler may be the resonator type, of which the design shall meet the following requirements:

1 For single channel resonant muffler, its channel diameter should not exceed 250mm; multi-channel may be adopted for the system with large flow, and the width of each channel may be 100mm ~ 200mm;

2 Dimension of cabinet length, width and depth of resonant muffler should be less than 1/3 of the wavelength of resonant frequency; perforating points shall be uniformly concentrated on the middle part of resonator; the length of perforated part should not be larger than 1/12 of the resonant frequency wavelength.

6.3.6 For the following situations, mufflers may be micro-punch or hair crack metal plate type:

1 Porous sound absorption material should not be used for muffler, and higher noise elimination amount is required to gain in wide band range;

2 Mufflers shall be used under medium conditions with high temperature, high humidity and high flow velocity.

6.3.7 In the noise elimination design for high-pressure jet noise, throttling decompression, pinhole jetting or throttling decompression and pinhole jetting composite muffler should be adopted; design of jet muffler shall meet the following requirements:

1 The throttling grade of throttle decompression muffler shall be determined according to the stayed pressure ratio, from Grade 2 ~ Grade 5; for the ultra-high-pressure condition, it may be Grade 8 at most;

2 Hole diameter of pinhole jetting muffler should be 1mm~3mm; center distance of hole shall be greater than 5 times of the hole diameter; the total aperture area shall be 1.5 times~2 times of the original air outlet area;

3 Throttling decompression and pinhole jetting composite muffler may

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sound absorbing treatment;

5 Determine the type, quantity and installation mode of sound absorbing materials.

7.2.2 The sound pressure level and A-weighted sound pressure level of six octave bands with center frequency of 125Hz~4,000Hz before sound absorption treatment of workshop may be measured or calculated according to Formula (5.2.2) of this Code.

7.2.3 The permissible sound pressure level of each octave band at noise reduction place shall be, as per the noise limits as specified in 3.0.1 of this Code, calculated by Formula (5.2.3) of this Code or selected according to those specified in Table 5.2.3-1. The required noise reduction amount by absorption may be obtained by deducting the permissible sound pressure level from the indoor sound pressure level before sound absorption treatment.

7.2.4 The average indoor sound absorption coefficient before sound absorption treatment may be obtained by measuring the reverberation time in the room or by calculating.

7.2.5 The proper average indoor sound absorption coefficient after sound absorption treatment may be calculated by the following formula according to the required noise reduction amount and average indoor sound absorption coefficient before sound absorption treatment:

$$\bar{\alpha}_2 = \bar{\alpha}_1 \cdot 10^{\frac{\Delta L_P}{10}} \qquad (7.2.5)$$

where,

ΔL_P - the noise reduction amount by absorption, dB;

$\bar{\alpha}_1$ - the average indoor random incident absorption coefficient before sound absorption treatment;

$\bar{\alpha}_2$ - the proper average indoor random incident absorption coefficient after sound absorption treatment.

Note: Formula (7.2.5) is applicable to the occasion when $\bar{\alpha}_2$ is less than or equal to 0.5.

7.2.6 The type, quantity and installation mode of sound absorption members shall be determined according to the requirements of the required average indoor sound absorption coefficient after sound absorption treatment

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and the requirements of Section 7.3 in this Code.

7.2.7 The effect of sound absorption design may be evaluated according to the noise reduction amount by absorption and the subjective sensation of indoor workers. The noise reduction amount by absorption may be obtained by measuring the noise levels at corresponding indoor position before and after sound absorption treatment or by measuring the reverberation time.

7.3 Component selection and design of sound absorption

7.3.1 The design and selection of sound absorption member shall meet the following requirements:

1 The sound absorption coefficient of sound absorbing materials may be provided by the manufacturer; where the manufacturer cannot provide it, it may be determined by measuring, estimating or looking up materials;

2 In the design of noise reduction by absorption for medium-high frequency noise, porous sound absorption materials such as conventional formed acoustic board, less dense or thin glass wool board may be adopted, and facing materials such as perforated plate may be arranged if necessary;

3 In the design of noise reduction by absorption for broadband noise, an air layer may be arranged after the materials or the thickness or surface density of porous sound absorption materials may be increased;

4 In the design of noise reduction by absorption for low frequency noise, the resonance sound absorption structure of perforated plate may be adopted; in order to increase the sound absorption bandwidth, proper amount of porous sound absorption materials may be filled in the resonator;

5 As for the design of noise reduction by absorption with higher indoor humidity or cleaning requirements, film-coated porous sound absorption materials or sound absorption structure of single- or double-layer micro-perforated plate may be adopted.

7.3.2 The selection of sound absorption treatment method shall meet the following requirements:

1 As for the sound absorption design for large noise reduction amount by absorption and small room area, sound absorption treatment should be carried out simultaneously for the roof and wall surfaces;

2 Where the required noise reduction amount by absorption is large and the workshop area is large, the sound absorber area of workshop should be 40% of the room roof area or 15% of the total indoor surface area; as for the sound absorption design for large-area flat workshop, sound absorption treatment

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Explanation of wording in this Code

1. Words used for different degrees of strictness are explained as follows in order to mark the differences in executing the requirements in this Code.

1) Words denoting a very strict or mandatory requirement:

"Must" is used for affirmation; "must not" for negation;

2) Words denoting a strict requirement under normal conditions:

"Shall" is used for affirmation; "shall not" for negation;

3) Words denoting a permission of a slight choice or an indication of the most suitable choice when conditions permit:

"Should" is used for affirmation; "should not" for negation;

4) "May" is used to express the option available, sometimes with the conditional permit.

2. "Shall comply with ..." or "shall meet the requirements of ..." is used in this Code to indicate that it is necessary to comply with the requirements stipulated in other relative standards and codes.

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Normative References

GB 50463, *Code for Design of Vibration Isolation*

GB 12348, *Emission Standard for Industrial Enterprises Noise at Boundary*

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EXPLANATION OF PROVISIONS

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Revision notes

GB/T 50087-2013 “Code for design of noise control of industrial enterprises” was approved and issued by the Housing and Urban-Rural Development on November 29, 2013.

This Code was revised based on GBJ 87-85 “Specifications for the design of noise control system in industrial enterprises”. The main drafting organization of the previous edition was Beijing Institute of Labor Protection Science. The drafting organizations were China Academy of Building Research, Institute of Acoustics, Chinese Academy of Sciences, Shanghai Civil Architectural Design Institute, Shanghai Chemical Design Institute, Ministry of Metallurgical Industry Chongqing Iron and Steel Design and Research Institute, Ministry of Metallurgical Industry Beijing Iron and Steel Design and Research Institute, Ministry of Machinery Industry Design and Research Institute, Eleventh Design Institute of Electronics Industry, the Fourth Planning and Design Institute of the Ministry of Aviation Industry, the Fourth Design Institute of the Ministry of Chemical Industry, China Environmental Science Research Institute. Main drafters were Fang Danqun, Chen Qian, Sun Jiaqi, Sun Fengqing, Dong Jinying, Wu Dasheng, Zhang Jingkai, Chen Daochang, Zhang Kuisheng, Xu Zhijiang, Liang Qihe, Mu Tiqian, Zhou Guangyuan, Yang Chenjun, Xiao Jinglan, Li Fangnian, Chen Lvhua, Zhu Ruzhou, Liu Huiyuan, Jiang Zhenquan, Feng Yuzheng, Feng Genquan, Yu Renxing, Qi Dan. Main technical contents of this revision were: 1. added the content of impulse noise limit; 2. made appropriate adjustment on noise limits for various workplaces; 3. modified relevant provisions on noise and vibration control measures.

During the process of revision of this Code, the drafting group, according to the opinions on noise control design for industrial enterprises collected in recent years, TOOK INTO ACCOUNT the current situation of industrial enterprises noise, the level of development of social economy, noise control technology development level, REVIEWED and FINALIZED this Code on the basis of extensive solicitation of opinions.

In order to facilitate the correct understanding and implementation of this Code by designer, constructer, scientific researcher and other relative personnel, the drafting group of “Code for design of noise control of industrial enterprises” made the provisions of this Code in the sequence of clause, section, article and described the purpose, reference specified by the provisions as well as relevant notices required attention during the implementation. However, this Code does not have the same legal effect as the normative text and is intended only as a reference for the user to understand and grasp the normative provisions.

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Code for design of noise control of industrial enterprises

(Explanation of Provisions)

1 General requirements

1.0.1 With the development of China's economy and science and technology, the number of industrial enterprises is increasing and the number of noise sources is increasing as well. This makes the noise problems caused by industrial enterprises become more prominent. And it is necessary to reduce the noise and improve the sound environment inside and outside the industrial enterprises. Therefore, when building industrial enterprises, noise control must be considered as an important factor.

1.0.2 In China's engineering construction practice, in addition to new construction, renovation and expansion projects, there are still a large number of technological transformation projects. Although the design of technological transformation project is different from many characteristics of new construction, renovation and expansion projects, there is no essential difference in the basic principles of noise control design and the design procedure of sound insulation, muffler, sound absorption and vibration isolation. Therefore, the provisions of this Code also apply to technological transformation projects.

1.0.3 The solving of the problem of industrial enterprises noise shall start from taking measures in the planning and design, site selection, the total plane design, workshop layout and noise control, etc. It shall consider these factors in the various design stages. If the noise problems wait to be solved after the project is completed, it shall not only require much more funding than that in the design phase, but also shall be limited by many unchangeable conditions which shall make it difficult to achieve the best noise reduction effect.

In order to improve the sound environment inside and outside the industrial enterprises, reduce the difficulty of solving the noise problem and reduce the cost of the latter, the noise control design of the new construction, renovation and expansion project shall be carried out in parallel with the engineering design. The construction projects that need to determine whether to take noise reduction measures after the completion of the project or not, shall be designed to take into account the space that the noise control measures shall occupy and the load that the building structure shall bear.

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The noise control design shall be participated by noise control professional and technical personnel mainly due to large workload, high demand of noise control for industrial enterprises. If this job is taken care by the professional noise control engineering and technical personnel, it shall ensure the noise control effect of industrial enterprises.

1.0.4 Noise control design in principle shall meet the requirements in all aspects, which is the main basis to evaluate the noise control design. For example, the improper setting of sound shield may indeed affect the operation, hinder the process and affect the equipment cooling; the use of noise absorption measures in a workshop with various and scattered noise sources may cost a lot but receive minimal noise reduction effect. Therefore, the noise control design shall take into account the production process, operation and maintenance, noise reduction effect and technical economy and other aspects.

The technical economy of noise control must be comprehensively understood. Noise control measures are not negative. Many noise reduction technology at home and abroad all play a useful role in energy consumption reduction, machine output increase. In many cases, the reduction of the radiated noise of the sound source often means an increase in mechanical efficiency. Noise reduction means also often reduce the vibration of the equipment body and buildings, thereby extending the life of buildings and equipment. Noise reduction can protect the health of workers, to ensure the normal work, to avoid accidents and to improve the environment. It is invisible savings.

1.0.5 There are three technical means to control noise: to eliminate noise from the sound source, to control noise in the noise propagation path and to protect the noise receiver. The noise elimination from sound source and the reduction of noise emission is more efficient and cost-saving than taking measures after noises are formed. For example, some low-noise fans are lighter than ordinary fan noise by more than 10dB(A). And the increase of low-noise fan cost is much less than the expense required by the noise control of ordinary fan. Therefore, the provisions of this Code reflect the principle of sound source noise reduction priority. Other noise control measures shall be taken for the use of low noise processes and equipment that still can not meet the noise limits.

1.0.6 There is no effective technical means at the current stage for the workplaces like weaving workshop, aircraft manufacturing maintenance workshop with various and scattered noise sources such as riveting sections; or because it is costly and impossible to promote; it is difficult to reduce its noise level below the noise limit. The provisions of this article actually provide an alternative approach for this particular case. It shall be noted that the application of this article provides only a very small number of exceptions, the occasions of which the current technical conditions can not meet the criteria.

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planning and the noise at the factory boundary meet the requirements of Clause 3 of this Code.

4.2.2 The noise propagates along the wind direction and the upwind direction. Due to the different direction of the sound line bending, there shall be a big difference. In order to minimize the impact on the residential area, the industrial enterprises shall be placed on the upper side of the minimum frequency of the urban residents'. Because the degree of indoor noise pollution in the building is very different from the opening and closing of the building's doors and windows, and the summer is the season that is most disturbed by the noise, the provisions on the summer are made.

4.2.3 The purpose of this article is to create a quieter external sound environment for a quiet industrial enterprise requiring the nature or use of internal work. Traffic artery refers to railways, highways, primary roads, secondary roads, urban expressways, urban trunk roads, urban secondary roads, urban rail transit routes, inland waterways, etc.

4.2.4 Although GB 12348 “Emission Standard for Industrial Enterprises Noise at Boundary” has specified the noise emission at boundary for plant, it is still necessary to use natural buffer areas near industrial plant site. That’s why the provisions of this article are made.

Natural buffer area refers to the natural isolation zone where the noise-sensitive buildings shall not be built near the plant site in the future ever, such as sand beach, wide water, farmland forest, mountain hills, etc.

4.3 General layout design

4.3.1 The principle of the establishment of this article is make separation between quietness and noise. High noise plant refers to the one that the internal noise has a significant impact on the external environment (such as blast furnace, air compressor station, forging workshop, engine test station, etc.). The provisions of article 3 mean that the doors and windows of the building requiring quietness must not face the noise source; the arrangement shall make most area of the building in a quieter area; the design of its height shall not make it exposed to the direct sound filed of many strong sound sources.

4.3.2 The provisions of “the main noise source shall be at low layout” mainly concern two aspects: from the view of terrain and floor. The low layout can effectively reduce the pollution range.

4.3.3 The purpose of this article is to narrow the scope of the noise impact and the number of persons affected. The road end layout refers to the road of which the ends do not connect or intersect with other roads.

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4.3.4 This article specifies the principles of taking noise control measures or maintaining the necessary protective distance. Since the degree of external interference from the noise source depends on a number of factors, this Code cannot make a specific value for the design of the protective distance. To take noise control measures in industrial enterprises, the investment scale is usually large. The vast spacing between buildings often occupy more land. Therefore, it shall be careful to select this measure. And it shall give priority to other aspects in the general layout design.

4.4 Technology, pipeline design and equipment selection

4.4.1 Several of the process design noise reduction methods listed in this article are summarized in engineering practice.

A typical example of a reduction in high pressure exhaust is the use of slippery parameters for power plant boiler furnace. Operation mechanization, operation automation, remote monitoring operation not only keep operators away from the sound source so as to reduce the exposure noise level, but also create conditions for the installation of acoustic enclosure, material delivery muffler channel and other facilities.

4.4.2 This article is to reduce the aerodynamic noise of the piping system, mainly the turbulence noise, while isolating the vibration of the solid sound caused by the vibration of the pipeline.

4.4.3 Many equipment manufacturers do not provide noise indicators of their products, which causes difficulties in equipment selection. This article only makes corresponding principle provisions on main noise source equipment based on the current situation. The main noise source equipment refers to the one that decides the noise level of the industrial enterprise.

4.4.4 Noise control equipment has been rapidly developed in recent years in China. Many mufflers, acoustic enclosures, sound absorbers, etc., can select stereotypes without the need for their own design and manufacturing. Refer to relevant product manual and other information for the selection of related product.

4.5 Workshop layout

4.5.1 This article is to reduce noise in certain areas of the workshop and to easily control the noise propagation, for example, the overall installation of acoustic enclosure for high noise equipment or the setting of sound insulation barrier. It shall also set acoustic booth for staff on duty.

4.5.2 The equipment with strong vibration generally has strong noise radiation. And it is easy to cause solid sound transmission.

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5.3.4 This article is for engineering practice. If the existing stereotypes cannot meet the requirements of sound insulation, the special sound insulation doors and windows shall be designed.

5.3.6 The damping layer is intended to eliminate the resonance and anastomotic effects of the thin metal plate and other lightweight materials. It can stick or spray a layer of damping material on the board surface. Commonly used damping materials are pitch-based damping, rubber-based damping, oil damping coatings, foaming materials, etc. The necessary space is reserved within the acoustic enclosure is mainly to reduce the standing wave effect.

5.3.7 The sound insulation barrier is close to the sound source or receiver set in order to increase the sound path difference between the diffuse sound and direct sound, thereby increasing its insertion loss. Set sound insulation barrier indoor. Perform corresponding sound absorption indoor. Otherwise the reflection of the walls and the roof shall form a reverberant sound field, the role of the sound barrier shall be significantly reduced. In theory, when the surface sound absorption coefficient of indoor walls, ceilings and sound insulation barrier tends to zero, the noise reduction of indoor sound barrier is equal to zero.

6 Muffler design

6.1 General requirements

6.1.1 This article specifies the requirements for muffler design.

In addition to reducing aerodynamic noise, the muffler design is also used to reduce radiation noise of the body. For example, if the blower room has a good sound insulation performance, operators are not required in the room, because the room needs to set an inlet, when the radiation noise of inlet affects the environment outside the room, it shall design and install the inlet muffler. The sound insulation of muffler, in principle, shall match with the sound insulation of the room.

6.1.2 This article was proposed because in the investigation, the performance of many mufflers was affected due to unreasonable installation part.

6.1.3 ~ 6.1.5 Three main evaluation indicators for muffler performance are: muffler volume (insertion loss), pressure loss and airflow regeneration noise. These three indicators must be balanced in unified consideration. When the length of the muffler is increased to a certain extent, the muffler does not increase linearly with the increase of the length due to the noise of the airflow. Meanwhile, the excessive demand for the muffler volume often leads to the

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complexity of the muffler structure, thereby increasing the pressure loss and the airflow regeneration noise, affecting the use of the muffler. Therefore, the muffler volume shall be based on the actual requirements. Excessive muffler volume shall not blindly be pursued.

The pressure loss is the difference between the average pressure at the inlet and the outlet of the muffler when there is a given steady flow in the muffler. Airflow regeneration noise is the noise generated by the airflow in the pipe or muffler. Its size is related to the velocity of the airflow and the pressure drop through the pipe or muffler. It shall reduce the function of the muffler and even make it completely ineffective.

6.1.6 The velocity of the airflow in the muffler directly affects the three indicators described in 6.1.3 to 6.1.5 of this Code. When the air velocity increases, the amount of muffling shall decrease, the pressure loss shall increase according to the square law, and the power of the regenerative noise shall increase by six times the law. Therefore, the airflow speed must be limited below a certain value. The limit of airflow speed specified in this article is based on practical experience.

6.1.7 This article specifies other requirements for mufflers other than the above three performance indicators.

6.2 Muffler design procedures and methods

6.2.1 This article specifies the steps of muffler design, i.e., the sequence of each stage. The muffler that meets requirements in Article 4 shall meet requirements of insert loss. Also, its pressure loss shall be within the range of normal operation of the equipment.

6.2.2 For the range of the sound power level determined for the multiplier band, this article specifies 8 octave frequency bands of which the center frequency is 63Hz ~ 8000Hz on the general situation. Any doubt on the data provided by the equipment manufacturer shall be confirmed by measurement, estimation or material search.

6.2.5 If the control points are outdoors, the room constant $R \rightarrow \infty$。

6.3 Selection and design of muffler

6.3.1 The formula of resistive muffler is the most commonly used formula in engineering practice both at home and abroad. Although this formula is still not accurate enough, it can still provide the most basic guidance on muffler design.

6.3.2 The upper limit cutoff frequency is the frequency at which the non-planar effect occurs in the pipe or muffler. When the channel cross

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The calculation formulas given in this Code are approximate formulas when $\bar{\alpha}_1$、$\bar{\alpha}_2$ are small. Therefore, the application conditions are limited.

7.2.7 The sound absorption design effect is evaluated by the subjective sensory effect of the interior staff. It mainly takes into account the small objective noise reduction of some noise absorption and reduction designs, but the indoor staff feel the noise environment has been greatly improved. Therefore, although the evaluation is subjective and qualitative, for the noise abstraction design, it has a practical significance. Therefore, it is also listed as an evaluation method.

For the noise absorption, it usually uses the "insertion loss method" to measure, that is to measure the 6-octave frequency band sound pressure level difference of A sound level of corresponding indoor measurement point and center frequency of 125Hz ~ 4000Hz before and after sound absorption. This method is greatly affected by the location of the test site. The test site must consider the distance from the sound source. The test site location must be marked in the measurement results. When it uses the reverberation time method to measure the noise reduction effect, it shall note that the reverberation time is established when the sound field is fully spread. After the indoor sound absorption, the sound field diffusion conditions shall become worse, the measurement results shall be different from the actual situation.

7.3 Component selection and design of sound absorption

7.3.1 Any doubt on the data provided by the sound absorption material manufacturer shall be confirmed through measurement, estimation or data search.

If the density of the sound absorption material is not specified in the provisions, it shall select according to the design requirements and economic requirements in the design. Design of noise absorption and noise reduction for medium and high frequency noise uses low density or thin glass wool board and other porous sound absorption material. It mainly refers that the low density or thin glass wool board has met the requirements for sound absorption. From the technical and economic point of view, the use of smaller or thin glass wool and other porous sound absorption material is feasible. It does not mean that the smaller the density or thin glass wool, the better the high-frequency sound absorption effect. Experience in engineering practice shows that the density of commonly used glass wool is 24 kg/m^3, 48 kg/m^3, etc.

After the porous material, set the air layer or increase the thickness and

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