BEFORE THE OIL AND GAS CONSERVATION COMMISSION
OF THE STATE OF COLORADO

IN THE MATTER OF CHANGES TO THE RULES AND REGULATIONS OF THE OIL & GAS CONSERVATION COMMISSION OF THE STATE OF COLORADO	)))))	CAUSE NO. 1R DOCKET NO. 200300071 TYPE: RULEMAKING

AFFILATED LOCAL GOVERNMENT COALITION'S RESPONSE TO PRE-HEARING STATEMENTS

Boulder County, the City of Lafayette, the City and County of Broomfield, the Town of Erie, the City of Fort Collins, the City of Longmont and the Northwest Colorado Council of Governments by and through its Water Quality/Quantity Committee (NWCCOG/QQ), participating as the Affiliated Local Government Coalition (the "ALGC"), by the undersigned, submits its Response to Pre-Hearing Statements for the above-captioned proceeding ("Mission Change Rulemaking.")

I. RESPONSE TO PARTIES' POSITION STATEMENTS

A. SB 181 established a shared regulatory framework in which COGCC and local governments have independent and separate authorities (and duties) to regulate siting and surface impacts.

The ALGC's essential position on the interplay of local and state authority is that, under S.B. 19-181 ("181" or "the Bill"), operators require both state and local approvals to conduct their operations and, if there is any conflict between those approvals, the more protective applies.[1] SB 181 created a shared regulatory framework in which the COGCC and local governments have independent authority and an independent duty to review oil and gas permit applications. Thus, the question is not whether or how COGCC should defer to a local government determination or

[1] S.B. 19-181, amending §§ 34-60-106(A), 34-60-131, C.R.S.

rule. COGCC does not regulate local governments; it regulates operators. The question is how the operator can ensure compliance with both local and state requirements.

A number of parties, including the industry trade associations, individual operators, Weld County, and the Rural Western Government Coalition, have presented a misplaced interpretation of 181 in their Prehearing Statements.[2] Per these parties, 181 severely diminished, if not entirely eliminated, COGCC authority to determine where and how oil and gas development should occur across the state. This position is evident in some parties' statements that COGCC should defer entirely to a local government siting decision[3] and in other statements that COGCC should defer to a local siting approval absent "extraordinary circumstances"[4] and should not regulate surface impacts where a local government does so.[5] The Commission must reject these specious arguments as fundamentally flawed. They ignore the fundamental purpose of the Legislature's amendment of the Oil and Gas Conservation Act's ("OGCA's") purpose and goals and ignore the clear text that establishes an independent authority and mandate for the COGCC to regulate where and how oil and gas development occurs in Colorado. Proposed redlines to Rule 302 to address these issues are provided in Appendix I.

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[2] Prehearing Statement of Garfield County and The Western & Rural Local Government Coalition on the 300 Series Rules, p. 3 (Jul. 13, 2020) ("WRLG PHS"); Prehearing Statement of The Board Of County Commissioners Of Weld County, Colorado, For the 100, 200, 300, 400, 500, and 600 Series Rules of The Colorado Oil and Gas Conservation Commission (Jul. 13, 2020) ("Weld PHS"); Colorado Oil & Gas Association's 300-Series Prehearing Statement (Jul. 13, 2020) ("COGA PHS"); Prehearing Statement of American Petroleum Institute Colorado Respecting the 300 Series Rules (Jul. 13, 2020) ("API PHS").

[3] *See e.g.,* Weld PHS.

[4] WRLG PHS, p. 3 (Jul. 13, 2020).

[5] COGA PHS; API PHS.

1. *COGCC must review all applications, taking into account any terms and condition imposed by local governments, to fulfill its new mandate to protect and minimize adverse impacts to public health, safety, welfare, the environment and wildlife.*

As set forth in our Prehearing Statement ("ALGC PHS"), 181 created a shared regulatory landscape wherein local governments and the COGCC each have independent authority to regulate oil and gas development in a manner that protects PHSWEW.[6] A fundamental purpose of the Bill was to reshape the mission of the COGCC from "fostering" development to "regulating in a manner that protects" PHSWEW.[7] This is also the fundamental purpose of this particular rule-making.[8] To meet its new mission, COGCC must review all applications for oil and gas development plans, or if applicable, Form 2A or drilling and spacing unit applications ("applications") for siting and location and must regulate adverse impacts, such as nuisance issues, that can adversely affect PHSWEW. The argument that the Legislature intended the COGCC to step aside and defer to local governments on critical issues that go to the heart of its new mission is simply baseless and wholly contrary to the express purpose of the legislation.

In establishing this shared framework, 181's drafters addressed two (of many) repeated problems that existed prior to the Bill's passage: (1) Colorado courts had struck down various local regulations that conflicted with COGCC rules under the principle that the COGCC was the primary regulator of oil and gas in the state and its regulations preempted local rules; and (2) COGCC's main objective as set forth in its enabling statute was to "foster" oil and gas development pursuant to cost effective and technically feasible rules. This regulatory landscape resulted in numerous courts barring local government attempts to regulate more protectively than

[6] §§ 29-20-104(1)(h); 34-60-102(1)(a)(I).
[7] § 34-60-102(1)(a)(I).
[8] COGCC, Mission Change Whitepaper (Nov. 1, 2019); COGCC, Draft Statement of Basis, Specific Statutory Authority, and Purpose, New Rules and Amendments to Current Rules of the Colorado Oil and Gas Conservation Commission, 2 CCR 404-1 (Mar. 15, 2020) ("SBAP").

the COGCC[9] and to lawsuits challenging the COGCC's failure to protect public health and the environment in its effort to maximize resource recovery.[10] Moreover, increasing public and governmental concern over numerous adverse impacts from oil and gas activities, based on a growing body of research, urged legislators to increase protections state-wide.[11]

With the passage of 181 the Governor and Legislature set out to fundamentally alter the way in which the state regulates oil and gas development and the ability of local governments to do the same.

First, they clarified and expanded local government authority over oil and gas development under § 29-20-104, C.R.S.. It is now incontrovertible that local governments may regulate various aspects of oil and gas development including, but not limited to, siting and surface impacts.

Second, they eliminated the state's ability to preempt a local rule that is more protective or stricter than a COGCC rule.[12] No longer can the COGCC overrule an attempt by a local government that wishes to adopt a stricter or more protective rule regarding the siting of a location or surface impacts. The state does, however, set a floor of minimum protections.

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[9] *City of Longmont v. Colorado Oil & Gas Association*, 369 P.3d 573 (Colo. 2016); *City of Fort Collins v. Colo. Oil and Gas Ass'n*, 369 P.3d 586 (Colo. 2016).
[10] *Martinez v. Colo. Oil & Gas Conservation Comm'n*, 2019 CO 3, 433 P.3d 22 (2019).
[11] See, e.g., McKenzie LM, et al., Childhood Hematologic Cancer and Residential Proximity to Oil and Gas Development, PLoS ONE, doi:10.1371/journal.pone.0170423 (Feb. 15, 2017); Fann, et al., Assessing Human Health PM2.5 and Ozone Impacts from U.S. Oil and Natural Gas Sector Emissions in 2025, Environ. Sci. Technol. (2018); McMullin, Exposures and Health Risks from Volatile Organic Compounds in Communities Located near Oil and Gas Exploration and Production Activities in Colorado, Int. J. Environ. Res. Public Health (2018); McKenzie LM, et al., Birth Outcomes and Maternal Residential Proximity to Natural Gas Development in Rural Colorado, Environmental Health Perspectives, 122:412–417; http://dx.doi.org/10.1289/ehp.1306722 (2014); Stacy SL, et al., Perinatal Outcomes and Unconventional Natural Gas Operations in Southwest Pennsylvania, PLoS ONE, 10(6): e0126425. doi:10.1371/journal.pone.0126425 (2015); Casey, J.A., et al., Unconventional natural gas development and birth outcomes in Pennsylvania, Epidemiology (2016); Currie, J., et al., Hydraulic fracturing and infant health: New evidence from Pennsylvania, Science Advances (2017); McKenzie, L.M., et al., Congenital heart defects and intensity of oil and gas well site activities in early pregnancy, Environment International (2019).
[12] § 34-60-131.

2. *The Plain Language of the Statute Establishes an Independent Duty for COGCC to Regulate Siting and Surface Impacts*

Throughout 181 the Legislature authorized and even *required* the COGCC to regulate oil and gas development, which necessarily includes review of location approvals and regulation of surface impacts. The Bill explicitly authorizes the Commission to regulate oil and gas development.[13] The phrase "oil and gas development" used in the Bill encompasses locations and siting (i.e., where development occurs) and regulation of surface impacts (i.e., how oil and gas development occurs). This grant of authority is not restricted to regulating oil and gas development where there are no relevant local regulations. Nor is this authority restricted to only regulating downhole issues. The legislature constrained authority in specific areas of the Bill, namely limiting local governments' authority to regulating "surface impacts."[14] However, contrary to the assertions of industry and others, 181 is clear that COGCC has an independent duty to determine both the where and the how of oil and gas development across the state.

The incorrect notion asserted by some parties – that local governments have primacy over siting and location, and therefore operators need not be concerned with COGCC standards that address these areas – is nowhere borne out by the text of 181.[15] The Legislature clearly contemplated that COGCC would be involved with siting and location determinations as it added a wholly new requirement to the OGCA for the COGCC to conduct alternative location analysis.[16] If COGCC were meant to defer entirely to every local government decision on siting, this provision to evaluate alternative locations other than that which is proposed by an operator would be rendered nearly meaningless as it would only apply in instances where local

[13] § 34-60-131.
[14] § 29-20-104(1)(h).
[15] WRLG PHS, p. 5; Weld PHS, pp. 3, 5.
[16] § 34-60-106(11)(c)(I).

governments do not regulate oil and gas facilities. Across Colorado, many local governments actively regulate oil and gas development. Indeed, many of those local governments are parties to this rulemaking and agree that the COGCC has an independent duty to review local siting approvals.[17] Notably, with this new grant of authority to analyze alternative locations, the legislature expanded, rather than narrowed, COGCC's authority to determine where oil and gas development occurs in the state.

The Legislature also clearly contemplated that operators would need to obtain a state, as well as local permit to drill. *See* § 34-60-106(f)(I)(A) (requiring operator to obtain permit from the commission, under rules prescribed by the commission before it can commence operations.) The Bill does not limit the requirement to obtain a state permit to only those instances where a local government does not regulate oil and gas development. Again, the notion that COGCC must step aside and give a local government complete control over the regulation of surface impacts and the siting of oil and gas development is simply not supported by the Bill.

Additionally, the fact that 181 requires an Operator to inform COGCC of a local government's "disposition" of an application does not demonstrate that the Legislature intended COGCC to relinquish all control over determining where development should occur, as some parties argue.[18] To the contrary, it is indicative of the shared responsibility that the state and local governments have to regulate development. Requiring an operator to inform the Commission as to the disposition of an application in no way demonstrates that local governments have primacy over development; rather, it simply suggests that local governments will *precede* COGCC in their review, rather than the reverse. This provision supports

[17] *See e.g.*, Prehearing Statement of Adams County for the 300 Series Rules, p.3 (Jul. 13, 2020); City of Aurora Prehearing Statement on the 300 Series Rules, p. 2, 5-8 (Jul. 13, 2020) ("Adams PHS"); La Plata County's and San Miguel County's Joint Prehearing Statement for 300 Rules Series, p. 4-5 (Jul. 13, 2020) ("La Plata PHS").
[18] WRLG PHS.

coordination and efficiency—two goals that industry and other local governments support.[19] It does not, however, demonstrate legal primacy.

B. COGCC has a duty to establish minimum state requirements that protect and minimize adverse impacts to PHSWEW.

Some parties argue that COGCC has no authority to impose its own surface impact regulations where a local government has adopted its own requirements.[20] This argument is at odds with the plain language of the statute as well as the fundamental goals of the statute.

As set forth in our Prehearing Statement, 181 enacted a shared regulatory framework wherein both the local government and COGCC have authority to regulate oil and gas development and to protect and minimize adverse impacts PHSWEW. Within this framework, local regulations that are stricter or more protective than the state's will apply.[21]

Acknowledging that COGCC has an independent duty to regulate surface impacts, and to set the floor in those areas, in no way alters, impairs or negates the ability of local governments to regulate oil and gas operations.[22] The Bill clarified the role of local governments as co-regulators with respect to surface impacts and siting. Thus, operators must comply with local regulations. However, nowhere does the Bill allow an operator to ignore or COGCC to abandon state regulations, simply because a local government has adopted its own requirements.

This framework of shared yet independent regulatory responsibility for protecting public health and the environment is akin to the one established in the Colorado Air Pollution Prevention and Control Act ("APPCA"). Per the APPCA, local governments may adopt emission

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[19] Adams PHS, p. 3; WRLG PHS pp. 2, 12; 300-Series Prehearing Statement of Noble Energy, Inc., P. 9 (Jul. 13, 2020); 300-Series Prehearing Statement of Occidental Petroleum, p. 9-10 (Jul. 13, 2020); 300-Series Prehearing Statement of PDC Energy, Inc., p. 9-10 (Jul. 13, 2020).
[20] Weld PHS, p. 7; WRLG 400 series PHS; COGA 400 Series PHS, p.3.
[21] § 34-60-131.
[22] *See* § 36-60-105(1)(b)(V).

control regulations that are more stringent than those promulgated by the Air Quality Control Commission ("AQCC").[23] Just because a local government may enact its own more stringent emission control requirement rather than one promulgated by the AQCC does not exempt an Operator from complying with the less stringent state control requirement. Rather, an operator must comply with both the state floor and any more protective local emission control regulations. The same is true here; namely, operators must comply with COGCC surface impact regulations as well as any more protective or strict local requirements.

C. COGCC should coordinate with local governments when exercising their independent duty to regulate oil and gas development.

While we believe it is clear that 181 sets forth a shared regulatory framework in which both local governments and the COGCC have authority, and COGCC has an affirmative duty, to protect and minimize adverse impacts, we support the concept that the COGCC and local governments should work together to minimize conflicts between their separate regulatory outcomes. Thus, we endorse the provisions in staff's June 26 draft that allow for local government and proximate local government consultation with Commission staff during staff's review of a local permit or approval.[24] We also support automatic standing for local governments in COGCC hearings on Oil and Gas Development Plans. We further support Adams County's suggestion that a local government's failure to consult with COGCC or a proximate local government during the local government approval process should be one of the Rule 302.b.(4) triggers for increased scrutiny by the COGCC.

Also to avoid unnecessary conflicts and uncertainty, where a local government has imposed requirements to a permit that exceed minimum state requirements set forth in COGCC

[23] § 25-7-128(1).
[24] COGCC, Draft Rule 302.g (June, 26, 2020).

rules, we would expect COGCC to include in its approval (if any) the locally-approved standards rather than supplanting them with its own conditions of approval.[25] For example, if a local government has approved of a site and requires the operator to install specific best management practices to mitigate noise, dust, light, odor, or visual impacts that are equally or more protective than COGCC requirements contained in Rules 423-427, the COGCC cannot preempt those locally-imposed Best Management Practices ("BMPs"). COGCC may determine that *additional* BMPs are necessary to better protect and minimize adverse impacts to PHSWEW, or to reduce cumulative impacts. In these instances, we expect the operator to work with COGCC and the local government to harmonize the requirements.

In recognition of the spirit of cooperation between the COGCC and local governments set forth in 181, we endorse the draft rule 302.b.(4) criteria in the June 26th draft with the changes included in our redlines and the redlines of those parties mentioned above. This provision sets forth criteria by which COGCC can require an operator to submit alternative locations in circumstances when the local government has approved of a facility in an area of concern (e.g., a floodplain) or a proximate local government objects. We support the rules including clear criteria that triggers the submission by the operator of alternative locations for COGCC review as this preserves the independent duty of the COGCC to review where oil and gas development occurs.

For these reasons, we object to COGA's revisions to Rule 422[26] and refer instead to the revisions to that rule provided with the ALGC PHS. Rule 422 should clearly reflect that operators must comply with COGCC requirements and with any *more protective or strict* local requirements.

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[25] ALGC Revised Pre-Hearing Statement 200 & 400 Series, p. 5 (Jul. 13, 2020) ("ALGC PHS").
[26] COGA 400 Series PHS, p. 2-3 (Jul. 13, 2020).

D. Evaluation of cumulative impacts is critical and should include all sources of impacts.

The ALGC's primary concern with cumulative impacts analysis in the June 26th draft is that it needs to be a lens through which the additive impacts of oil and gas development are assessed in a more holistic way and in the context of a given region. Effective evaluation of cumulative impacts is not accomplished solely by an operator submitting a plan along with a list of other application checklist items; it is a way that COGCC should be looking at the development impacts of oil and gas singularly, incrementally, and collectively in a region. That is: what are the individual impacts that result from a new oil and gas facility itself, how do each of the individual impacts add up, and how do the successive additions of oil and gas development impact a region overall? It involves analysis at two levels: (i) evaluation of the various impacts of a facility (light, noise, odor, traffic, etc.) that lead to the entirety of its impacts, and (ii) how those impacts incrementally and collectively affect a region overall. Level one can be easily evaluated by COGCC staff; level two could benefit from establishment of a framework or program that collects data to help monitor and assess regional impacts from a baseline level.

It is critical for the COGCC, together with CDPHE, to provide leadership and act as a resource in order to measure the effects additional oil and gas development in context and across the state. For these reasons and since development of a program, including scope of the region, could be rather involved, the ALGC requested further discussions on cumulative impacts analysis to address these underlying principles, rather than proposing specific rule redlines. The ALGC generally agrees with other parties such as the Sierra Club, Earthworks, LOGIC (League of Oil and Gas Impacted Coloradans) and the Larimer Alliance for Health, Safety and Environment ("Citizen Groups"); 350 Colorado and Physicians for Social Responsibility

("350/PSR"), and Climate Reality that evaluation of cumulative impacts must be built on data-driven, measurable criteria and standards wherever appropriate, and that such standards should consider existing, reasonably foreseeable, and lifecycle impacts and recipients of those impacts. The ALGC specifically supports the use of data and scientific material such as is cited in 350/PSR's, the Citizen Groups', and Climate Reality's prehearing statements.

The ALGC disagrees with the statements of the Western and Rural Local Governments ("WRLG") that COGCC should give no consideration to the cumulative impacts of traffic, noise, light, dust, and odors. As stated in Sections A-C above, the COGCC is directed by 181 to provide a protective floor of regulations that all communities in the state, including those that do not regulate oil and gas development, can rely on. COGCC's duty in this regard is broad and cannot ignore some of the most impactful and disruptive aspects of oil and gas development. Moreover, COGCC should be looking at every proposed oil and gas facility in light of *all* the impacts it will impose on surrounding areas and how to mitigate them, as those impacts build upon each other and upon similar impacts from existing or reasonable foreseeable land uses in the same area and contribute to the broader region.

E. Alternative location analysis is also critical and should be strengthened rather than weakened.

Analysis of alternative locations for oil and gas development ("ALA") also must be conducted by the COGCC, not operators, and with respect to identifiable criteria. ALA is a way of evaluating the appropriateness of a proposed oil and gas location as compared to others in an effort to select the optimal site for an area. The ALGC provided specific redlines to Rule 304.b.(2) along with its discussion of governing principles in the ALGC PHS.

1. *COGCC should conserve resources by pausing its proceedings if its ALA leads to a conclusion different than the local government's conclusion.*

The ALGC supports the approach in current Rule 304.b(2) and 302.b(4) that provides specific criteria to trigger an ALA by the COGCC, with the additions suggested by the ALGC and Adams County in their PHS. However, the current ALA process provides an opportunity for the COGCC and all parties to conserve their resources. As Adams County proposed in its addition at Rule 304.b(2).D., if the COGCC determines in an ALA that a different location than the one approved by the local government is more protective of PHSWEW, the ALGC requests that COGCC should pause its proceedings on the application rather than issuing an approval of the alternative site.

Under the COGCC's and local governments' independent authorities, an operator needs both COGCC and local approval to proceed with development. Thus, even if the COGCC issued an approval of an alternative site, the operator would not be able to begin construction without also obtaining local approval. Rather than take staff and party time to go all the way through the COGCC ALA process to end in a stalemate, it would be wise for COGCC to pause its review of the application and allow the operator to seek local approval of the new site or revise its plans all together.

2. *ALA is required where an Oil and Gas Location is near sensitive features protected by COGCC's new mission.*

Several parties, primarily WRLG, API, and COGA, asserted that the triggers for sites requiring an ALA can only key off human habitations or frequently-used buildings (i.e., "populated areas").[27] Those parties point to Section 12 of the Bill that relates ALA rules to development near "populated areas." However, the language in the Bill does not require the interpretation given by WRLG, API and COGA. The provision directs COGCC to (i) "adopt an alternative location analysis," and to (ii) "specify criteria" to identify proposed development near

[27] API 330 Series PHS, pp. 7-9; COGA 300 Series PHS, pp. 6-7; WRLG 300 Series PHS, p. 10.

populated areas.[28] Thirdly, the provision states that oil and gas locations near populated areas "will be subject to" an ALA.[29] Thus, while COGCC must specify criteria (and already has in the draft rules) that define when development is "near populated areas," those criteria do not restrict the scope of ALA. Just because those particular locations near populated areas "will be subject to" ALA does *not* mean that *other* oil and gas locations, such as those near other sensitive features of value, may not *also* be subject to ALA.

The Bill emphasizes that COGCC is to regulate in a manner that protects "the environment and wildlife resources" along with public health, safety, and welfare.[30] The March 15, 2020 Draft Statement of Basis and Purpose ("SBAP") recognizes that ALA "is closely related to issues central to the Mission Change" including the need for COGCC "rules to better protect and minimize adverse impacts to . . . the environment and wildlife resources."[31] If there is any ambiguity in the 181 directive regarding ALA, the overall purpose of the Bill and the Mission Change Rulemaking should guide the interpretation to the one most protective of both public welfare *and* environmental and wildlife resources.

3. The ALGC supports other parties' statements regarding aspects of ALA.

The ALGC agrees with Adams County that an ALA must consider enough sites, and distinct enough sites, to make the comparison of alternatives meaningful. We also generally support the Citizen Groups' comments on ALA. The ALGC also agrees with Commerce City's suggestion that COGCC's evaluation of alternative locations should precede the operator's submission of a Form 2A for the proposed site. This way, the Form 2A process will not foreclose the possibility of preferable locations and prematurely focus the inquiry. In addition,

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[28] S.B. 19-181, § 12, p. 19.
[29] *Id.*
[30] *Id*. at § 6, pp. 6-7.
[31] SBAP, p. 2.

the ALGC agrees with Commerce City's suggested additions to factors involved in the ALA – the operator's other current or reasonably foreseeable activity in the area, planned truck routes, planned pipeline routes. Finally, the ALGC generally agrees with the criteria Commerce City suggested for evaluating alternative locations, but would add that the primary consideration should be which of the alternative sites can be designed and mitigated to protect PHSWEW (and, if none, that the application must be denied). Additional redlines related to ALA are contained in Appendix I.

F. COGCC Setbacks

1. COGCC Setbacks should be 2000'

In order to ensure the COGCC meets its mandate to protect and minimize adverse impacts to public health, we reiterate our suggestion that the state adopt a 2,000-foot setback from a residential Building Unit or a High Occupancy Building Unit. We suggest this in lieu of the proposed 1,500-foot setback from 10 or more residential Building Units or 1 High Occupancy Building Unit, R. 604.c.(2). Our suggestion is based on the setback recently adopted by the City and County of Broomfield[32] and rooted in the recent Colorado Department of Public Health and Environment study that found that 2,000 feet is a more appropriate minimum setback than 1,500 feet.[33]

2. Operators must comply with COGCC setback requirements as a floor

Several industry parties have taken the position that local governments should have complete control over siting decisions and this control allows operators to ignore COGCC setback

[32] City and County of Broomfield Municipal Code, 17-54-070, https://library.municode.com/co/broomfield/codes/municipal_code?nodeId=TIT17ZO_CH17-54OIGALAUSRE
[33] CDPHE, State health department publishes oil and gas health risk study (Oct. 17, 2019), https://www.colorado.gov/pacific/cdphe/news/oil-and-gas-health-risk-study

requirements.[34] Under 181, the COGCC has an independent duty to protect public health, safety, and welfare, including protection of the environment and wildlife resources.[35] Allowing oil and gas facilities at unsafe distances would chip away at the protections owed to all Coloradoans and does not fit with the Bill's mandate. Furthermore, it skews the tone of 181 to suggest that setting minimum state requirements for setbacks as a safety measure detracts from local government control over siting. In practice, local governments have substantial control over siting decisions, and an operator must comply with both the state and the local government's requirements in order to proceed with an oil and gas development.

A point the ALGC made in its Pre-hearing Statement, which we would like to clarify, is the suggestion that in certain circumstances both local governments and the COGCC may approve locations that are within required setbacks. To clarify this point, the current draft rules allow for locations that do not comply with stated setbacks in limited circumstances if waivers or variances are obtained from the COGCC. Because local governments must be at least as protective of PHSWEW as the COGCC, they also could allow such siting under the same terms as approved by the state (if waivers like those required by COGCC have been obtained by the operator). Such an approval would still trigger additional COGCC review under Rule 304.b(2) and 302.b(4), through which COGCC may approve the location if (i) all necessary waivers or variances are obtained and (ii) the COGCC's independent review concludes that the site, with all conditions of approval imposed by the local government or the COGCC, is protective of PHSWEW.

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[34] *See* API 600 Series PHS; COGA 600 Series PHS; Prehearing Statement Of Crestone Peak Resources Operating, LLC; Prehearing Statement of Great Western Operating Company, LLC, COGCC Rule Series 600; Prehearing Statement of Nickel Road Operating LLC, COGCC Rule Series 600; 600-Series Prehearing Statement of Noble Energy, Inc.; 600-Series Prehearing Statement of Occidental Petroleum Corporation; 600-Series Prehearing Statement of PDC Energy, Inc.
[35] § 34-60-106(2.5)(a).

3. Multi-family dwellings of four or more units should qualify as HOBUs

COGA and other parties argue that multi-family dwellings should contain at least 15 living units to qualify as High Occupancy Building Units.[36] They reason that other facilities qualifying as HOBUs "regularly serve[] 50 or more persons" and, therefore, HOBU residences should also house a similar number of people.

The ALGC disagrees with the principle behind this argument – that only a denser area deserves protections and a lesser number of people do not. All Coloradans, one or many, deserve the same level of protection sought by these rules. To this end, the ALGC PHS recommended that a 2,000' setback should be applied to any number of residences or an HOBU. If the COGCC adopts that approach, the definition of multi-family dwelling qualifying as an HOBU is less important strictly with respect to setbacks. However, to the extent that the definition of HOBU comes into play in other areas of the rules, the ALGC strongly supports the COGCC intention to include multi-family dwellings of four or more units at a minimum.

G. COGCC must regulate surface impacts broadly.

Some parties suggest that mitigation plans for noise and light should not be required in all instances, instead suggesting they only be required when development occurs in populated areas.[37] We disagree. The Bill clearly includes protection of the environment and wildlife resources in COGCC's new mission, so these features should not be left without consideration. Noise and light can be extremely disruptive to wildlife, as well as to livestock in agricultural areas. Moreover, unpopulated areas may include scattered rural residences that should be protected and may include open space lands where people choose to recreate and study or enjoy

[36] COGA 300 Series PHS, p. 11-12.
[37] *See e.g.*, COGA 400 Series PHS, p. 7 (Jul. 13, 2020); Prehearing Statement of Highpoint Operating Corporation, COGCC 400 Series Rules, p. 4 (Jul. 13, 2020).

night skies. The ALGC's position is that the COGCC should be looking at every proposed oil and gas facility in light of *all* the impacts it will impose on surrounding areas (singularly or cumulatively), as those impacts collectively impact an area.

Similarly, some parties suggest that the trigger for the operator undertaking additional steps to control nuisance impacts should be less than Staff proposes.[38] For example, Staff has proposed operators conduct noise monitoring at nearby receptors when such receptors are located within a 2,000 ft radius of the oil and gas facility.[39] Similarly, Staff proposed operators use BMPs to reduce odors whenever there are receptors within 2,000 ft of oil and gas operations or facilities.[40] Various factors can affect the distance a nuisance such as odor, light or noise travels including topography, wind speed and direction, air quality, the type of equipment used on site, and what specific operations are occurring onsite. The COGCC has a duty to protect and minimize adverse impacts to public health, welfare, the environment and wildlife. In order to ensure its rules implement this mandate, we suggest COGCC act conservatively in determining in what proximity to homes its more robust requirements apply. We support the current 2,000 ft. distance for this reason, rather than a lesser distance.

1. Noise

Some parties also argue that noise monitoring not be required during completion, recompletion, stimulation and well maintenance activities.[41] We disagree. These activities can be significant sources of noise and therefore operators should be required to monitor for noise during these activities as proposed.

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[38] *See* 400-Series Prehearing Statement of Noble Energy, Inc.; 400-Series Prehearing Statement of Occidental Petroleum Corporation, 400-Series Prehearing Statement of PDC Energy Inc.
[39] COGCC Draft Rule 423.a.(5) (June 26, 2020).
[40] COGCC Draft Rule 426(c) (June 26, 2020).
[41] *See* 400-Series Prehearing Statement of Noble Energy, Inc.; 400-Series Prehearing Statement of Occidental Petroleum Corporation, 400-Series Prehearing Statement of PDC Energy Inc.

Extraction Oil & Gas, Inc., argues that it cannot be required to comply with a lower maximum permissible noise level than required by the COGCC rules after it has designed a facility.[42] We disagree. Operators can add mitigation measures or replace equipment to reduce noise after they have begun construction or operations. Indeed, Extraction did just that with respect to its operations in Broomfield where it changed out equipment on its coiling and tubing rig that resulted in significantly lower noise levels, and it electrified all engines in an attempt to reduce noise after they had been installed during the fracking phase. If noise from a particular facility results in significant impacts to public health and welfare, the Director may require the Operator to mitigate these impacts in order to protect public health and welfare.

2. Lighting

The ALGC agrees with COGA that the technical terminology used related to lumens versus footcandle/lux is inaccurate, and that the draft rules would be unenforceable. The ALGC also agrees "there are multiple regulatory approaches to assess, technical experts have not been engaged fully to analyze these different regulatory approaches, and adequate time has not be [sic] provided for stakeholder engagement in this review."[43]

However, the ALGC disagrees with COGA that portable lighting should not be included as part of the light mitigation plan. Instead, the ALGC recommends that operators submit a mitigation plan that specifically addresses how portable lighting will be mitigated during the pre-production period. The ALGC also does not agree with COGA that light mitigation plans for permanent lighting be submitted 30-90 days prior to construction, and instead believe they should be submitted as part of an OGDP and be part of COGCC's review. The ALGC disagrees with COGA that providing cut sheets of light fixtures is duplicative; cut sheets are the only way

[42] Extraction Oil & Gas, Inc.'s Combined 400-, 500- and 600-Series Prehearing Statement, p. 2 (Jul. 13, 2020).
[43] COGA 400 Series PHS, p. 6.

to verify if fixtures fully shielded and directionally downlit. Finally, the ALGC has concerns over COGA's lumen budget per square foot and land use approach. The concept and recommendations are derived from the Model Lighting Ordinance (MLO), which was jointly written by the Illuminating Engineer Society and International Dark Sky Association. The MLO explicitly states the model is intended for adoption by local governments as a zone district overlay, and is *not* appropriate for adoption at the state level.[44] Finally, the ALGC recommends a color temperature of 3000 Kelvins on lights to reduce sky glow and protect public health and wildlife.

H. Comprehensive Area Plans should be utilized as a planning tool to help assess cumulative impacts.

Comprehensive Area Plan ("CAPs") are an important planning tool that will assist COGCC in its new mission. In particular, because the evaluation of cumulative impacts remains an important area of ongoing discussion, we point out that CAPs – which look at broader areas of development – can be extremely helpful in conducting meaningful cumulative impacts analyses.

Some parties argue that COGCC should offer expedited timelines for processing CAPs. The ALGC disagrees. Because CAPS can be such a useful way to fully incorporate evaluation of cumulative impacts, they should not be rushed. In fact, we recommend a required pre-application meeting among COGCC, the operator, the Relevant and any Proximate Local Governments, CDPHE and any other relevant federal and state agencies (e.g., BLM, CPW) prior to submission of a CAP. This will allow all interested parties to assist in putting together a truly comprehensive plan that can consider all potential issues. In addition, also because of the great value of comprehensive planning, we suggest that COGCC have the authority, such as it has in the existing Rule 513 Geographic Area Plan, to require a CAP if, in consideration of a single

[44] See page 4 of https://www.darksky.org/wp-content/uploads/bsk-pdf-manager/16_MLO_FINAL_JUNE2011.PDF

OGDP that proposes large-scale development or is close to a number of pending or recently approved OGDPs, the CAP process would better allow for the careful analysis and planning needed to protect PHSWEW. Proposed redlines to the CAP rule are contained in Appendix I.

I. New Rule 305.a(2).L. is necessary and appropriate.

In its Supplemental Preliminary Party Input, the ALGC stated concerns over evidence of mineral rights in hearings. In response to the API PHS, we now state that we strongly support the addition of Rule 305.a(2).L. It is critical that permit applicants meet their burden to prove their fundamental entitlement to the permit requested. Mineral rights are notoriously difficult to determine, or for other parties to confirm. Requiring applicants to provide the most basic documentary basis for the ownership claims is an essential, fundamental aspect of due process.

Along with the deed or lease required by 305.a(2).L, COGCC should also require, at a minimum, the conveyance document by which the current occupant assumed the rights in that foundation document. Such conveyances are particularly difficult to find in public records. Because a full chain of title for each tract would be impractical, an initial, new requirement of both the foundational right-granting document *and* the most recent conveyance of those rights into the applicant's hands would represent a substantial step forward in fairness and due process in COGCC proceedings. Additional redline suggestions to this end are attached.

J. COGCC should be liberal in its determination of Affected Persons.

COGA argues for a very restrictive approach to who can qualify as an Affected Person.[45] The ALGC opposes COGA's recommended changes and refers the COGCC, and COGA, to the inclusive policies and intentions for Rule 507 identified in the SBAP. The ALGC strongly supports the approach laid out there.

[45] COGA 500 Series PHS, pp. 3-4.

K. Rules 209-211 should retain discretion.

COGA argues against Rules 209, 210, and 211 where they each give the COGCC discretion to require tests and surveys, mandate corrective actions, and require plugging and abandonment or closure where “reasonably necessary to protect or minimize adverse impacts to” PHSWEW.[46] Consistent with the “standardless standards” theme among industry parties, COGA argues that protecting PHSWEW is too vague and subjective a standard. While the ALGC agrees with other parties that argue for elucidating standards for COGCC’s reviews wherever possible, the bottom line is that the COGCC is now statutorily mandated to protect and minimize adverse impacts to PHSWEW. While COGCC will likely need to continue working on identifying its standards of review, by rule or by policy, the ALGC strongly believes COGCC should maintain all proposed discretion in these rules in service of its fundamental mission to regulate in a manner that protects PHSWEW.

Under the appeal right in Rule 209 and COGA’s procedural suggestions for Rule 211, which the ALGC does not oppose, operators will get ample opportunities to inquire into and answer COGCC’s views on why a facility or location reasonably and necessarily requires closure. If the operator ultimately believes COGCC has failed to establish a foundation for such a conclusion, it has legal remedies.

While COGCC will likely need to continue working on identifying its standards of review to protect PHSWEW throughout its reviews, by rule or by policy, it should maintain the discretion to require testing, mandate corrective actions, and order facility closure in service of its fundamental mission to regulate in a manner that protects PHSWEW.

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[46] COGA 200 Series PHS, pp. 4-10.

L. If Wellbore Spacing Units are reestablished, their procedures must be amended.

COGA and HighPoint Operating argue that Wellbore Spacing Units (WSUs) should not be eliminated in draft Rule 402.[47] The ALGC has no opinion on the industry parties' stated necessity for WSUs, but if the COGCC considers revising them, the procedure for establishing them requires significant improvement.

Under current Rule 318A, WSUs are established in a backhand, nontransparent manner. Essentially, operators submit a letter to the Director requesting establishment of a WSU and give notice to affected mineral owners. Parties are then entitled to object on four extremely limited bases. Rule 318A.e(5)B. If the WSU is administratively granted without a hearing on objections, there is no requirement of a COGCC order or other formal statement of that approval. Rule 318A.e.(5)E. Thus, most completed WSUs are only reflected in their final form by implication from the COGCC's approval of a Form 2. This makes it extremely difficult for anyone to determine whether a WSU currently exists, or to determine its size or exact location.

If the COGCC reinstates WSUs, they must follow a procedure aligning more closely with procedures for drilling and spacing units ("DSUs") that ensures: (i) an unrestricted opportunity for parties to object to a proposed WSU on the same grounds available for DSUs; and (ii) an identifiably and locatable order establishing the WSU, whether it is approved administratively or after a hearing.

M. Penalties

COGA argues that language giving a presumptive 35% discount on penalties if an operator self-discloses a violation should be retained.[48] The ALGC disagrees. Responsible

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[47] COGA 400 Series PHS, p. 12-13; HighPoint Operating 400 Series PHS, pp. 2-3.
[48] COGA PHS at 6.

operators should always voluntarily disclose violations of applicable rules. This should be the default condition and not something for which an operator is rewarded. The draft rules appropriately allow self-disclosure to be a mitigating factor that the COGCC may consider in imposing a penalty. It should not be a virtually de facto entitlement to escaping more than a third of the penalty that has been pre-determined as appropriate for the subject violation.

II. WITNESS LIST

1. Kim Sanchez, Deputy Director of Planning and LGD, Boulder County. Ms. Sanchez will provide testimony regarding evaluation of cumulative impacts, alternative location analysis, comprehensive area plans, and other land use and local government planning matters within her knowledge.
2. Kelly Smith, Senior Environmental Planner, City of Fort Collins. Ms. Smith will provide testimony to support changes to lighting provisions in draft Rule 424.
3. Jonathan Ferdinand, Vibratech, Inc. Mr. Ferdinand will provide testimony to support noise provisions in draft Rule 423. His resume is attached as Appendix II.

III. EXHIBIT LIST

ALGC 1: ANSI S12.9-2005/Part 4.

RESPECTFULLY SUBMITTED this 31st day of July, 2020.

BOULDER COUNTY, COLORADO

By:______________________________
Katherine A. Burke, Atty. Reg. #35716
Assistant County Attorney

Attorney for Boulder County, Colorado

By:______________________________
Kimberly Sanchez
Deputy Director – Planning and LGD
Boulder County

CITY OF LAFAYETTE, COLORADO

By: *<u>/s/ Elizabeth Paranhos</u>*
Elizabeth Paranhos, Atty. Reg. #39634
deLone Law, Inc.

Attorney for City and County of Broomfield, Colorado

CITY AND COUNTY OF BROOMFIELD, COLORADO

By: *<u>/s/ Elizabeth Paranhos</u>*
Elizabeth Paranhos, Atty. Reg. #39634
deLone Law, Inc.

Attorney for City and County of Broomfield, Colorado

CITY OF FORT COLLINS

By: *<u>/s/ Kelly Smith</u>*
Kelly Smith, PLA
Senior Environmental Planner

TOWN OF ERIE

By: *__/s/ Barbara Green__*
Barbara Green
Sullivan Green Seavy
Attorney for Town of Erie

CITY OF LONGMONT

By:*___/s/ Brad Schol_______*
Brad Schol, Special Projects Manager

NORTHWEST COLORADO COUNCIL OF GOVERNMENTS

By: *__/s/ Barbara Green__*
Barbara Green
Sullivan Green Seavy

Attorney for Northwest Colorado Council of Governments

CERTIFICATE OF SERVICE

I hereby certify that a true and correct copy of the foregoing **AFFILIATED LOCAL GOVERNMENT COALITION'S RESPONSE TO PRE-HEARING STATEMENTS** was served electronically, this 31st day of July, 2020, to the following:

DNR_COGCC.Rulemaking@state.co.us

_/s/Stephanie Adamson_____________
Stephanie Adamson, Legal Assistant

APPENDIX 1
Additional redlines to 300 Series

PERMITTING PROCESS
300 SERIES
[prior changes in orange; new changes in blue]

302. LOCAL GOVERNMENTS.

a. Nothing in the Commission's Rules constrains the legal authority conferred to Local Governments by Colo. Rev. Stat. §§ 24-65.1-101 *et seq.*, 29-20-104, 30-15-401, or any other statute, to regulate Oil and Gas Operations in a manner that is more protective or stricter than the Commission's Rules.

b. **Local Government Siting Information.** With their Oil and Gas Development Plans, or, if applicable, with their Form 2A or drilling and spacing unit applications, Operators will submit to the Director certification from the Relevant Local Government LGD that:

(1) The Relevant Local Government does not regulate the siting of Oil and Gas Locations;

(2) The Relevant Local Government regulates the siting of Oil and Gas Locations, and has denied the siting of the proposed Oil and Gas Location;

(3) The Relevant Local Government regulates the siting of Oil and Gas Locations, and the proposed Oil and Gas Location does not meet any of the criteria listed in Rule 302.b.(4); or

(4) The Relevant Local Government regulates the siting of Oil and Gas Locations, and the proposed Oil and Gas Location meets one or more of the following criteria:

A. An alternative location analysis complying with or exceeding the criteria in Rule 304.b was not completed by the Relevant Local Government for the proposed Oil and Gas Location and results submitted to the Director for review;

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B. A Formal Consultation Process with the Director and any Proximate Local Governments was not initiated by the Relevant Local Government or the operator for the proposed Oil and Gas Location;

C. The proposed Working Pad Surface did not undergo a formal review and approval process by the Relevant Local Government that included opportunity for public comments to be received and considered;

D. The proposed Working Pad Surface is within:

i. 500 feet of 1 or more residential Building Unit(s);

ii. 1500 feet of 10 or more residential Building Units; or

iii. 1500 feet of 1 or more High Occupancy Building Unit(s);

E. The proposed Working Pad Surface is less than 2000 feet from the property line of a School Facility or Child Care Center, and the Relevant School Governing Body has not provided a signed waiver pursuant to Rule 604.b.(1);

F. The proposed Working Pad Surface is within 1500 feet of a Designated Outside Activity Area;

G. The proposed Working Pad Surface is less than 2000 feet of a municipal or county boundary, and the Proximate Local Government objects to the location or requests an alternative location analysis;

H. The proposed Working Pad Surface is within a Floodplain;

I. The proposed Oil and Gas Location is within a Surface Water Supply Area;

J. The proposed Oil and Gas Location is within the boundaries of, or is immediately upgradient from, a mapped, visible, or field-verified wetland or riparian corridor;

K. [Placeholder for 1200 Series High Priority Habitat];

L. The Operator is using or intends to use a Surface Owner protection bond pursuant to Rule 703 to access the proposed Oil and Gas Location; or

M. The proposed Working Pad Surface may affect Disproportionately Impacted Communities, because the proposed Oil and Gas Location is within or immediately adjacent to:

i. A U.S. census tract in which more than 50% of the population meets the definition of a "minority population" pursuant to the U.S. Environmental Protection Agency's (EPA) Technical Guidance for Assessing Environmental Justice in Regulatory Analysis (June 2016), or in which the minority population percentage of the tract exceeds the minority population percentage of the County, whichever is greater. Only the June 2016 edition of EPA's Technical Guidance for Assessing Environmental Justice in Regulatory Analysis applies to this Rule; later amendments do not apply. All materials incorporated by reference in this rule are available for public inspection during normal business hours from the Public Room Administrator at the office of the Commission, 1120 Lincoln Street, Suite 801, Denver, CO 80203. In addition, these materials may be examined at the U.S. Environmental Protection Agency, Region 8, 1595 Wynkoop St, Denver, CO 80202, and is available online at https://www.epa.gov/sites/production/files/2016-06/documents/ejtg_5_6_16_v5.1.pdf.

Field Code Changed

ii. A U.S. census tract classified as a "low" income area by the Federal Financial Institutions Examination Council's (FFIEC) Online Census Data System (2019). Only the 2019 data in the FFIEC's Online Census Data System applies to this Rule; later years' data do not apply. The FFIEC's Online Census Data System 2019 data for all counties in Colorado are available for public inspection during normal business hours from the Public Room Administrator at the office of the Commission, 1120 Lincoln Street, Suite 801, Denver, CO 80203. In addition, these materials may be accessed online at www.ffiec.gov/census/default.aspx.

Field Code Changed

iii. A U.S. census tract has a minority population percentage that exceeds the minority population percentage of the county in which the proposed Oil and Gas Location is located, and is classified as a "moderate" income area by the FFIEC's Online Census Data System (2019), as incorporated by reference in Rule 302.b.(4).J.ii.

iv. The exterior boundaries of the Southern Ute Indian Reservation and subject to the Commission's jurisdiction pursuant to Rule 201.d.(2), and the Southern Ute Indian Tribe objects to the proposed Oil and Gas Location or requests an alternative location analysis.

c. **Director's Review of Local Government Siting Information.**

(1) For proposed Oil and Gas Location listed in Rule 302.b.(1) or (3), the Director will conduct a ~~siting~~ review pursuant to the Commission's 300 Series Rules.

(2) For proposed Oil and Gas Location listed in Rule 302.b.(2), the Commission will not review the ~~approve the proposed~~ Oil and Gas Location ~~without a hearing before the Commission~~.

~~(3) For proposed Oil and Gas Locations listed in Rule 302.b.(3), the Director will defer to the Relevant Local Government's siting disposition.~~

~~(4)~~**(3)** For proposed Oil and Gas Locations that meet one or more of the criteria listed in Rule 302.b.(4), the Operator will ~~submit~~ conduct an alternative location analysis pursuant to Rule 304.b.(2), unless the Director determines in the Completeness Determination that an alternative location analysis is not necessary to protect public health, safety, welfare, the environment, or wildlife resources. The Director may not waive the alternative location analysis requirement for any Oil and Gas Location that meets the criteria listed in Rule 302.b.(4).A–C.

d. With their Oil and Gas Development Plan, or, if applicable, with their Form 2A, Operators will state whether the proposed Oil and Gas Location is subject to the requirements of § 24-65.1-108, C.R.S. because it is located in an area designated as one of State interest.

e. **Notice to Relevant and Proximate Local Governments.** An Operator will notify any Relevant and Proximate Local Governments that it plans to submit an Oil and Gas Development Plan no less than 30 days prior to submitting an Oil and Gas Development Plan. The notice will comply with the procedural and substantive requirements of Rule 303.e.(2) & (3).

f. **Local Government Waiving Authority.**

(1) At any time, a local government may, by providing written notice to the Director on a Form 29, Local Government Information, and any relevant Operators:

A. Waive its right to receive notice under any or all of the Commission's Rules; or

B. Certify that it chooses not to regulate the siting of Oil and Gas Locations.

(2) The Commission will maintain a list of Local Governments that have certified to the Director that they have chosen not to regulate the siting of Oil and Gas Locations, or receive any category of notice otherwise required by the Commission's Rules. This list will be posted on the Commission's website.

(3) A Local Government may withdraw a waiver at any time by providing written notice to an Operator and the Director on a Form 29, Local Government Information. Upon receiving such notice, the Director will immediately remove the Local Government from the Rule 302.f.(2) list on the Commission's website.

g. **Local Government Consultation.** Within 45 days after an Operator provides notice of a proposed Oil and Gas Development Plan, and prior to the Director making a Director's Recommendation that the Commission approve or deny the Oil and Gas Development Plan, Relevant Local Governments or Proximate Local Governments may request, and will be provided, an opportunity to consult with the Operator and the Director. The Director or Operator will promptly schedule a Formal Consultation Process meeting. Topics for Formal Consultation Process meeting will include, but not be limited to:

(1) The location of access roads, Production Facilities, and Wells; and

Commented [A1]: As noted in our PHS, we do not believe the COGCC should review an application that has been denied by a local government. The operator requires both a local and state approval; therefore, it is a waste of state resources to review an application that a local government has denied. Moreover, as set forth in our Response, the COGCC cannot overrule a local government siting determination as local governments have independent regulatory authority over oil and gas development.

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(2) Necessary and reasonable measures to avoid, minimize, and mitigate adverse impacts to public health, safety, or welfare or the environment, or wildlife resources.

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304. FORM 2A: OIL AND GAS LOCATION ASSESSMENT APPLICATION.

b. Information Requirements. All Form 2A, Oil and Gas Location Assessments Applications must include the following information:

(2) Alternative Location Analysis.

A. Applicability: This Rule 304.b.(2) applies to any proposed Oil and Gas Location:

i. Within a local government jurisdiction that does not regulate Oil and Gas Operations; or

i.ii. That meets the criteria listed in Rule 302.b.(4); or

ii.iii. For which the Director or Commission otherwise determines that an alternative location analysis is necessary to evaluate whether the proposed Oil and Gas Location reasonably protects and minimizes adverse impacts to public health, safety, welfare, the environment, and wildlife resources.

B. Contents of an Alternative Location Analysis. If an alternative location analysis is required, the Operator will prepare an analysis that identifiesidentify all potential alternate locations that may be considered for siting of the Oil and Gas Location. A minimum of three alternative locations must be included and all alternative locations must be sufficiently distanced and sufficiently distinct to allow for meaningful analysis (e.g., the alternatives must be 1,000 feet apart or substantially different from each other due to geologic features, natural areas, or topography). The Operator will provide . Operators will also submit the following information:

i. One or more maps or recent aerial images showing the proposed area of mineral development, the Operator's proposed Oil and Gas Location, all Operator-identified technically feasible alternative locations, all proximal existing and permitted Oil and Gas Locations, all relevant jurisdictional boundaries, traffic and access routes for each location, and all Rule 302.b.(4) criteria met by the proposed location or any Alternative Location.

ii. A data table for the proposed Oil and Gas Location and each alternative location, with all measurements made from each proposed Working Pad Surface, that lists the following information:

aa. All Rule 302.b.(4) criteria met;

bb. Distance to the nearest Disproportionately Impacted Community, as identified by Rule 302.b.(4).J;

cc. Distance to any municipal or county boundaries that are within 2000 feet, and the names of the Proximate Local Government(s);

dd. The Relevant Local Government's land use or zoning designation, and Local Government permit status, if applicable;

ee. Current land use, and plans for future land use at and proximal to the location;

ff. Distance to nearest wetland, surface water, Surface Water Supply Area, or other potentially sensitive water resource receptor, and a description of that receptor;

gg. Distance to nearest High Priority Habitat;

hh. Anticipated method of right-to-construct and surface ownership.

iii. A narrative description of the proposed site and each alternative location including:

aa. Whether mineral extraction is feasible from the location;

bb. Topographic, geologic, or development features that may exacerbate or mitigate adverse impacts from the location;

~~hh.~~cc. A rationale for the selection or non-selection of each location.

C. The Director may request that the Operator provide any additional information, or analyze additional locations for the Oil and Gas Location if the Director believes that additional analysis or information is necessary for the Director's and Commission's review of the public health, safety, welfare, environmental, and wildlife impacts of the locations the Operator analyzes.

D. In conducting the alternative location analysis, the Director will consider the following criteria:

i. Distance from those features listed in Rule 302.b.(4) and any other sensitive features;

ii. Comparative traffic and transportation infrastructure impacts from each location;

iii. Comparative land disturbance at each location;

iv. Existence of feasibility of accessible infrastructure, including pipelines and electric power;

v. Comparative impacts on wildlife, plant communities, wetlands, and other natural resources;

vi. Comparative impact on water bodies and drinking water sources;

vii. Comparative noise, light, and odor impacts on residents and frequent users of the surrounding area;

viii. Comparative public health concerns from each location;

ix. The degree to which each site allows for impact mitigation measures, such as berms and landscaping;

x. Comparative difficulty of complete reclamation at each location;

~~C.~~**E.** ~~If, after conducting the alternative location analysis, the Director finds that a location other than the one proposed by the Operator would be more protective of public health, safety, welfare, the environment and wildlife, the Director will include that determination~~

in the recommendation under Rule 306. If the Relevant Local Government has previously approved a different location, the Operator will be required to obtain local government approval of the alternate site selected by the Director before beginning operations.

D.F. Should the Director determine a proposed Oil and Gas Location reviewed, as part of the alternative location analysis pursuant to Rule 304.b, is more protective of public health, safety, welfare, the environment, or wildlife resources than that of the Oil and Gas Location previously approved by a Relevant Local Government, then the Director will notify the Relevant Local Government of such determination within 5 business days and immediately pause any further evaluation of the Oil and Gas Development Plan or Form 2A at the Commission until such time that the Relevant Local Government can evaluate and approve, where applicable, the alternative location pursuant to Commission and local regulations.

E.G. Should any alternative location presented by the Operator be contained partially or wholly within another jurisdiction than that of the Relevant Local Government with siting authority for the primary location or approved location, where applicable; the Director will immediately notify those local governments and initiate a Formal Consultation Process on all alternative locations.

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305. APPLICATION FOR A DRILLING AND SPACING UNIT.

a. Procedural Requirements.

(1) Operators seeking to create a new drilling and spacing unit, or to modify an existing drilling and spacing unit, will file a drilling and spacing unit pursuant to Rule 503.g.(2). If the proposed drilling and spacing unit is part of an Oil and Gas Development Plan application, the drilling and spacing unit application will be included with the hearing application for that Oil and Gas Development Plan.

(2) All drilling and spacing unit applications will include the following information:

……

L. For at least one portion of a mineral tract within the proposed unit, documentation showing the applicant's status as an Owner within the unit. Acceptable forms of documentation include, but are not limited to:

i. Mineral deed or memorandum;

ii. Mineral lease or memorandum; or

iii. Any other agreement confirming the applicant's right to drill into and produce from a pool, or a memorandum of such agreement; and

iv. Any conveyance document by which the rights granted in the deed, lease or other agreement were conveyed or assigned to the Applicant.

……

c. Standards for Approval. In determining whether to recommend that the Commission approve or deny a proposed drilling and spacing unit, the Director will consider whether the proposed drilling and spacing unit:

(1) Protects and minimizes adverse impacts to public health, safety, welfare, the environment, and wildlife resources, and protects against adverse environmental impacts on any air, water, soil, or biological resource resulting from Oil and Gas Operations, including with respect to the cumulative impacts of establishing the drilling and spacing unit;

(2) Prevents waste of oil and gas resources;

(3) Avoids the drilling of unnecessary Wells; and

(4) Protects correlative rights

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306. Director's Recommendation on the Oil and Gas Development Plan.

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b. Director's Recommendation.

(1) Approval. The Director may recommend that the Commission approve an Oil and Gas Development Plan that:

(i) Complies with all requirements of the Commission's Rules; and

(ii) In the Director's judgment, protects and minimizes adverse impacts to public health, safety, welfare, the environment, and wildlife resources, and protects against adverse environmental impacts on any air, water, soil, or biological resource resulting from Oil and Gas Operations, including with respect to the cumulative impacts of the development proposed in the Oil and Gas Development Plan.

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307. COMMISSION CONSIDERATION OF THE OIL AND GAS DEVELOPMENT PLAN.

b. Commission's Consideration of Director's Recommendation.

(1) Approval. The Commission may approve an Oil and Gas Development Plan that complies with all requirements of the Commission's Rules, and protects and minimizes adverse impacts to public health, safety, welfare, the environment, and wildlife resources, and protects against adverse environmental impacts on any air, water, soil, or biological resource resulting from Oil and Gas Operations, including with respect to the cumulative impacts of the development proposed in the Oil and Gas Development Plan. The Commission may add any conditions to the approval of an Oil and Gas Development Plan that it determines are necessary and reasonable to ensure compliance with all requirements of the Commission's Rules or to protect public health, safety, welfare, the environment, and wildlife resources or to protect against adverse environmental impacts on any air, water, soil, or biological resource resulting from Oil and Gas Operations.

(2) Denial. If the Commission determines that an Oil and Gas Development Plan does not provide necessary and reasonable protections for public health, safety, welfare, the environment, and wildlife resources, or that it fails to protect against adverse environmental impacts on any air, water, soil, or biological resource resulting from Oil and Gas Operations or fails to meet the requirements of the Commission's Rules, including with respect to the cumulative impacts of the development proposed in the Oil and Gas Development Plan, the Commission may deny the Oil and Gas Development Plan. The Commission will identify in the record the basis for the denial.

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314. COMPREHENSIVE AREA PLANS.

d. Submission Procedure.

(1) One or more Operators (collectively, the "Operator") may apply for a CAP at any time by submitting the application materials specified in Rule 314.e. electronically pursuant to Rule 503.g.(9).

(2) If the Director determines during the course of reviewing an OGDP, in light of pending or recently approved OGDPs in geographical proximity and the cumulative impacts of proposed and existing development in the affected area, that a CAP would provide for more effective planning and protection of public health, safety, and welfare and the environment and wildlife resources, the Director may require the operator to initiate and attend the meeting described in Rule 314.d.(3). If, after that meeting, the Director determines that a CAP is required, the operator will coordinate with other operators in the CAP area and follow the procedures in this Rule 314.

(3) Prior to submitting Rule 314.e. materials, the Operator will initiate and attend a meeting among the Operator, the Relevant Local Government(s), any Proximate Local Governments, COGCC, CDPHE, CPW, and any relevant federal agencies to discuss the CAP. The meeting will address the scope and design of the CAP, particular issues or areas of concern, ongoing coordination among these stakeholders, and any other topics of interest to the parties.

(4) The Operator will coordinate with the Director to ensure that the Operator submits all information necessary for the Director and Commission to fully evaluate the CAP's cumulative impacts on public health, safety, welfare, the environment, and wildlife.

(5) At any time after a CAP application is submitted, the Director may request any information necessary to review the CAP application. The Operator will provide all requested information before the Director issues the Director's Recommendation.

(6) When the Director has obtained all information necessary to fully review the CAP's cumulative impacts on public health, safety, welfare, the environment, and wildlife resources, the Director will make a completeness determination.

e. Informational Requirements for Comprehensive Area Plan. At a minimum, the Operator will submit the following materials as components of its CAP application.

(1) Contact Information.

A. The name, telephone number, and e-mail address for the primary contact person about the CAP for each Operator.

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B. The name, telephone number, and e-mail address for the Local Governmental Designee, if applicable, of every Local Government within the CAP's boundaries.

C. The name, telephone number, and e-mail address for all Local Governments within 2000 feet of the CAP's boundaries.

D. Contact information for all persons who must receive notice pursuant to Rule 314.f.(1).C.

(2) **Fees.** Payment of the full filing and service fee required by Rule 301.e.

(3) **Certification of stakeholder meeting.** A brief report certifying that the meeting required under Rule 314.d.(3) occurred and the points of discussion, including any decisions or plans arrived at by the attendees.

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PROFESSIONAL QUALIFICATIONS

Jonathan Ferdinand

Vibration and Noise Specialist

Education

- Inter-College Ecology Graduate Degree Ph. D Program – course work completed 1998
- M.S. – Science and Ecology, Pennsylvania State University, 1996
- B.S. – Science, Pennsylvania State University, 1991

Continuing Education Programs

- Efficient Blasting Techniques, Blast Dynamics Inc., 3.0 CEU
- 5th Soil Dynamics Short Course, Missouri University of Science and Technology, 16 Professional Development Hrs.
- Geotechnical Instrumentation for Field Measurements, University of Florida, 1.5 CEU
- Structural and Geotechnical Monitoring, Campbell Scientific, 3.8 CEU
- Structural Vibration Analysis, Design and Troubleshooting, American Society of Civil Engineers, 3.1 CEU
- Applied Acoustics and Noise Control Theory and Applications, AVNC Consulting Engineers in Acoustics and Vibration, 3.0 CEU
- Air Dispersion Modeling-AERMOD Regulatory Dispersion Model, Trinity Consultants, 2.0 CEU
- Geotechnical Instrumentation and Monitoring Workshop, American Society of Civil Engineers, 2.0 CEU
- CR1000/Loggernet Training and Programming, Campbell Scientific, 2.8 CEU
- Visible Emissions Evaluation Program - EPA FRM 9, The Pennsylvania State University, 1.0 CEU
- OSHA 29 CFR 1910.120 40 Hr. Hazardous Waste Training
- MSHA-HAZCOM Surface, Metal, Non-Metal, Underground Safety Trained
- New York City - MTA Track Safety Training
- Philadelphia - PATCO Track Safety Training

Professional Background

May 2004 to Present

Vibra-Tech Engineers, Inc. – Hazleton, PA

Present Position – Vibration and Noise Specialist

Mr. Ferdinand is responsible for developing scope of work and cost proposals for vibration, noise, dust and geotechnical monitoring projects. In addition, he completes field installations as well as data analysis and project report preparation in cooperation with our structural and geotechnical engineer.

In the area of geotechnical monitoring, Jonathan is familiar with geotechnical instrumentation including tilt beams and sensors, crack gauges (LVDT and vibrating wire), convergence meters, strain gauges, multiple point borehole extensometers, inclinometers and various fluid based settlement monitoring systems. As part of this monitoring, he is also experienced in the configuration and programming of remote data logger systems for geotechnical data collection, as well as SQL data base and web page integration for web hosting of data.

Publications

- "Noise and Dust: A Sound Approach to a Cloudy Issue," AGG1 2013 Academy and Expo, San Antonio, TX (2013)
- "Particulate Matter as an Air Pollutant, Past, Present, and Future," Proceedings of the 5th Biennial Blasting Vibration Technology Conference, Key West, FL (2004)
- "Particulate Matter as an Air Pollutant - Measurement Methods and Federal Regulations," Environmental Resource Management 430 - Penn State University, University Park, PA Guest Lecturer - 2003 to 2008

Professional Experience

- Pennsy Supply—Millard Aggregates, Annville, Pennsylvania
  As part of Millard's permit requirements for reporting water quality and usage, Vibra-Tech installed a network of Static Water Level (Piezometers), Total Dissolved solids (Conductivity), Total Suspended Solids (Turbidity), and pH sensors. All sensors are connected to remote wireless data nodes to provide real time monitoring and reporting to Millard personal and State Regulator.
- Western Pennsylvania Conservancy—Frank Lloyd Wright – Fallingwater, Mill Run, Pennsylvania
  As part of a recent preservation program, Vibra-Tech was retained by the Western PA Conservancy to install and operate a remote system of geotechnical tilt and crack monitoring devices to track movement of cantilevered terraces and existing cracks within the structure.
- INTECH Construction, Inc.—Curtis Institute of Music, Philadelphia, Pennsylvania
  Responsible for vibration monitoring as well as bi-axial (vertical and horizontal) tilt monitoring of existing structures and PATCO subway tunnel immediately adjacent to the demolition and construction activity. All vibration and bi-axial tilt sensors are remotely monitored.

- Triton Construction Inc.—Oliverhouse Condominium Project, Brooklyn, New York
  Provide remote vibration and settlement profile monitoring within approximately two hundred and thirty linear feet of MTA subway tunnel. For settlement monitoring, a web based data collection and reporting system has been installed to provide monitoring results directly to the client. This project web site is updated every hour with the latest readings.

- Solomon R. Guggenheim Foundation—Museum Restoration Project, Manhattan, New York
  As part of the Guggenheim museum exterior restoration project, Vibra-Tech was retained to conduct long term structural monitoring prior to the restoration. In addition, a long term monitoring program was put into place after restoration work to evaluate the effectiveness of several building restoration techniques and materials. Monitoring for this project includes crack displacement, convergence measurements of walls, and strain measurements of various materials.

- WRS Compass Environmental—White Plains, New York
  During deep excavation immediately adjacent to a Con Ed substation, Vibra-Tech has provided a system of automated vertical tilt monitoring for a retaining wall near the substation and excavation. All vertical tilt monitoring data is collected via a remote data logger system equipped with a visual alarm. A web based data collection and reporting system has also been configured to provide the client with immediate access to all data and project criteria alarms for allowable wall movement. For this project, the web page data is updated every 30 minutes.

- Pennsy Supply Inc.—Small Mountain Quarry, Dorrance, Pennsylvania
  Retained as consultant to determine potential noise impacts to surrounding community resulting from relocation of quarry equipment closer to residential homes. Conducted ambient noise monitoring and noise level projection analysis. Provided expert testimony to local zoning hearing board.

- St. Lawrence Cement Company—Camden, New Jersey
  Determine the noise and vibration impact that the St. Lawrence Cement Operation was having on the surrounding community, including truck noise along the designated truck route during delivery to the plant. Vibration impact due to truck traffic was also evaluated.

- Preferred Real Estate Investment, Inc.—Conshohocken, Pennsylvania
  The purpose of this study was to record the sound and vibration levels relative to the operation of the nearby SEPTA Regional Rail, Chestnut Hill Branch. A noise and vibration assessment based on land use type was conducted as per Federal Transit Administration guidelines.

- Aquarion Water Company of Connecticut—Stamford Water Treatment Plant
  Monitored particulate matter as PM10 during blasting and construction activities during the expansion of the Stamford water treatment plant. Dust monitoring was conducted at four locations in the community surrounding the site. All PM10 levels were compared to the established criteria set for the project.

- Hines, Inc.—Devon Energy World Headquarters, Oklahoma City, Oklahoma
  In order to monitor potential ground settlement and static water level adjacent to the construction of the tower, Vibra-Tech installed three (3) Multiple Point Borehole Extensometers (MPBX) and one (1) Piezometer. Each MPBX consists of three vibrating wire transducers that detect settlement at three depths; ground surface, 10 feet, and 25 feet below the ground surface. All data for the project automatically posted to a project web site.

- Marble Collegiate Church Restoration – New York, New York
  As part of the current restoration project at the Marble Collegiate Church (circa 1854), Vibra-Tech, was retained to develop vibration criteria specific to protecting the plaster finishes during the church restoration. During planned roof truss and basement level rock removal activities, Vibra-Tech provided both vibration and structural monitoring services. We also provided vibration monitoring on the plaster as well as crack displacement monitoring of existing plaster cracks. Tilt monitoring and strain monitoring were monitored at existing roof truss tie rods.

Depositions and Testimony

Client: Kirkpatrick & Lockhart Nicholson LLP
Project: St. Lawrence Cement Co., L.L.C, Camden, New Jersey
Deposed as expert witness for Class Action Law Suit –settled out of court

Client: Rynearson, Suess, Schnurbusch, & Champion
Project: Burkeemper v. Fred Webber and Magruder Limestone, Floresant, Missouri
Deposed as expert witness for law suit – settled out of court

Client: Shelton-Valdez Attorneys at Law
Project: Smith et al. v. H. E. Butt Grocery Co., Corpus Christi, Texas
Deposed as expert witness for Class Action Law Suit – settled out of court

Client: Pennsy Supply Inc.
Project: Small Mountain Quarry Expansion, Dorrance, Pennsylvania
Provided expert testimony regarding noise - Dorrance Township Zoning Hearing Board

Client: York Building Products
Project: Merrick Farm Mine Project Queen Anne's County, Maryland
Provided expert testimony regarding noise- Queen Anne's County, Maryland Zoning Board

Client: Amerikohl Mining, Inc.
Project: Proposed Curry Surface Mine, Dunbar Township - Fayette County PA
Provided expert testimony regarding noise – Fayette County Zoning Board

Client: Byler Materials, LLC.
Project: Application for Major Extraction Permit, Queen Anne's County, Maryland Zoning Board.
Provided expert testimony regarding noise- Queen Anne's County, Maryland Zoning Board

Client: Cynthia Kennelly – Home owner
Project: Kennelly v. Russell's Hauling – West Wyoming, PA
Small Claims Court – Luzerne County, PA
Provided expert testimony regarding noise

Client: Martin Marietta Materials, Inc.
Project: Baker v. Martin Marietta, Inc.
Circuit Court, Jackson County, MO. Expert witness in case regarding sound level testing and results measured along designated truck route.

ALGC EXHIBIT 1
Docket 200300071

ANSI S12.9-2005/Part 4
(Revision of ANSI S12.9-1996/Part 4)

AMERICAN NATIONAL STANDARD

Quantities and Procedures for Description and Measurement of Environmental Sound – Part 4: Noise Assessment and Prediction of Long-term Community Response

ANSI S12.9-2005/Part 4

Accredited Standards Committee S12, Noise

EXHIBIT NO. 5D
NELSON
1-19-17
Rabin' Monroe, RDR, CRR

Standards Secretariat
Acoustical Society of America
35 Pinelawn Road, Suite 114E
Melville, New York 11747-3177

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ANSI S12.9-2005/Part 4
(Revision of ANSI S12.9-1996/Part 4)

AMERICAN NATIONAL STANDARD

QUANTITIES AND PROCEDURES FOR DESCRIPTION AND MEASUREMENT OF ENVIRONMENTAL SOUND — PART 4: NOISE ASSESSMENT AND PREDICTION OF LONG-TERM COMMUNITY RESPONSE

Secretariat:

Acoustical Society of America

Approved by:

American National Standards Institute, Inc.

Abstract

This Standard specifies methods to assess environmental sounds and to predict the annoyance response of communities to long-term noise from any and all types of environmental sounds produced by one or more distinct or distributed sound sources. The sound sources may be separate or in various combinations. Application of the method of the Standard is limited to areas where people reside and related long-term land uses. This Standard does not address the effects of intrusive sound on people in areas of short-term use such as parks and wilderness areas, nor does it address other effects of noise such as sleep disturbance or health effects. This Standard does not provide a method to predict the community response to short-term, infrequent, non-repetitive sources of sound.

AMERICAN NATIONAL STANDARDS ON ACOUSTICS

The Acoustical Society of America (ASA) provides the Secretariat for Accredited Standards Committees S1 on Acoustics, S2 on Mechanical Vibration and Shock, S3 on Bioacoustics, and S12 on Noise. These committees have wide representation from the technical community (manufacturers, consumers, trade associations, organizations with a general interest, and government representatives). The standards are published by the Acoustical Society of America as American National Standards after approval by their respective Standards Committees and the American National Standards Institute.

These standards are developed and published as a public service to provide standards useful to the public, industry, and consumers, and to Federal, State, and local governments.

Each of the accredited Standards Committees [operating in accordance with procedures approved by American National Standards Institute (ANSI)] is responsible for developing, voting upon, and maintaining or revising its own Standards. The ASA Standards Secretariat administers Committee organization and activity and provides liaison between the Accredited Standards Committees and ANSI. After the Standards have been produced and adopted by the Accredited Standards Committees, and approved as American National Standards by ANSI, the ASA Standards Secretariat arranges for their publication and distribution.

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Foreword

[*This Foreword is for information only, and is not a part of the American National Standard ANSI S12.9 - 2005/Part 4 American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound - Part 4: Noise Assessment and Prediction of Long-Term Community Response.*]

This standard comprises a part of a group of definitions, standards, and specifications for use in noise. It was developed and approved by Accredited Standards Committee S12 Noise, under its approved operating procedures. Those procedures have been accredited by the American National Standards Institute (ANSI). The Scope of Accredited Standards Committee S12 is as follows:

> *Standards, specifications, and terminology in the field of acoustical noise pertaining to methods of measurement, evaluation, and control; including biological safety, tolerance, and comfort, and physical acoustics as related to environmental and occupational noise.*

This standard is a revision of ANSI S12.9-1996/Part 4, which has been technically revised. The changes in this edition harmonize with the new material added to ISO 1996-1:2003. This includes a minor change to high-energy impulse noise assessment (less than 1 dB) so that it is totally in sync with ISO. Second, as appropriate, ISO assessment adjustments have been included. Also, some new cautionary notes from ISO are added to the estimation of "highly annoyed" as notes to the informative annex. A new Annex G addresses complaints in the limited situation of high-energy impulsive noise.

The current edition of ISO 1996-1:2003 actually began as the text of ANSI S12.9 - 1996/Part 4. However, the ISO standard was substantially revised during the WG and committee deliberations. For example, ISO recognizes the more general Day-Evening-Night Sound Level in contrast to S12's Day-Night Sound Level. Nighttime hours are not given in ISO because they vary from country to country. The terms "background" sound and "ambient" sound are NOT used in ISO because they have diametrically opposed meanings in different countries and regions. There are many other differences of this nature. ISO uses "rating" sound level; ANSI uses "adjusted" sound level, etc.

At the time this Standard was submitted to Accredited Standards Committee S12, Noise for approval, the membership was as follows:

R.D. Hellweg, *Chair*

R.D. Godfrey, *Vice-Chair*
S.B. Blaeser, *Secretary*

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.... P.D. Schomer (Alt.)

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.... R.R. James (Alt.)

John Deere .... K. Cone

Larson Davis Laboratories .... L. Davis
.... K. Cox (Alt.)

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National Hearing Conservation Association .... K. Michael

National Institute for Occupational Safety and Health .... W.J. Murphy

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.... R. Fischer (Alt.)

Noise Pollution Clearinghouse .... L. Blomberg

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Plantronics, Inc. .... A.K. Woo

Power Tool Institute, Inc. .... W.D. Spencer
.... M. Hickok (Alt.)

Quest Technologies, Inc. .... M. Wurm
.... P. Battenberg (Alt.)

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.... N. Alem (Alt.)

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U.S. Army Construction Engineering Research Laboratories .... M. White
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U.S. Department of Transportation .... A. Konheim

U.S. Army Human Research and Engineering Directorate .... T.R. Letowski
.... L. Babeu (Alt.)

U.S. Naval Surface Warfare Center Carderock .... M. Craun
.... J. Niemiec (Alt.)

Individual Experts of Accredited Standards Committee S12, Noise, were:

P.K. Baade
L.L. Beranek
E.H. Berger
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B.M. Brooks
A.J. Campanella
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G.S.K. Wong

Working Group S12/WG 15, Measurement and Evaluation of Outdoor Community Noise, which assisted Accredited Standards Committee S12, Noise, in the development of this standard, had the following membership.

P.D. Schomer, Chair

G.A. Daigle
K.M. Eldred
A.G. Konheim

L.S. Finegold
L. Pater

G.A. Luz
A.H. Marsh

Suggestions for improvements of this standard will be welcomed. They should be sent to Accredited Standards Committee S12, Noise, in care of the Standards Secretariat of the Acoustical Society of America, 35 Pinelawn Road, Suite 114E, Melville, New York 11747-3177. Telephone: 631-390-0215; FAX: 631-390-0217; E-mail: asastds@aip.org

Introduction

0.1 Part 1 of ANSI S12.9 defines day-night average sound level and other descriptors of community noise. Part 2 of ANSI S12.9 describes measurement procedures. ANSI S12.9/Part 5 provides a recommended relation between long-term usages of land and day-night average sound level for purposes of long-term land-use planning. Since the early 1970s, many agencies within the United States of America have used day-night average sound level as the fundamental descriptor to predict the community response to environmental sounds.

0.2 The 1978 seminal paper by T.J. Schultz demonstrated the efficacy of day-night average sound level for predicting the annoyance response of a community as a result of noise from highway traffic, railroad, aircraft, and some industrial sites. Implementation of the concept of day-night average sound level for prediction of community response often combined the sound exposures from such sources.

0.3 Day-night average sound level has been used to predict the annoyance response of communities to types of noises that were not included in the Schultz database for the relation between the percentage of a population expressing high annoyance and the corresponding day-night average sound level. These additional types of noises include sounds with special characteristics, such as impulsiveness, dominant pure tones, rapid onset, and strong low-frequency content.

0.4 Technical reports and articles published in refereed engineering and scientific journals demonstrated that the community response to these sounds may be predicted, provided suitable adjustments are applied. A practical procedure to apply these adjustments is provided by this Standard.

0.5 For situations where activity interference is the major concern, use of adjusted day-night average sound level or adjusted total day-night sound exposure may not be appropriate. For example, day-night average sound level without adjustments may be a better predictor of speech interference than adjusted day-night average sound level. Descriptors such as maximum A-weighted sound level, time-above, or speech interference level may be even more appropriate for predicting speech interference.

American National Standard

QUANTITIES AND PROCEDURES FOR DESCRIPTION AND MEASUREMENT OF ENVIRONMENTAL SOUND — PART 4: NOISE ASSESSMENT AND PREDICTION OF LONG-TERM COMMUNITY RESPONSE

1 Scope

1.1 This Standard specifies methods to assess environmental sounds and to predict the potential annoyance response of a community to outdoor long-term noise from any and all types of environmental sounds from one or more discrete or distributed sound sources. The sound sources may be separate or in various combinations. Application of the prediction method is limited to areas where people reside and to related long-term land uses.

NOTE The long-term period is typically one year. However, the user of this Standard can employ these methods for shorter periods of time, but they should report this change and not attempt to predict percent highly annoyed using Clause 8.3 or Annex F, since the Annex F data all represent long-term situations.

1.2 This Standard describes adjustments for sounds that have special characteristics so that the long-term community response to such sounds can be predicted by a method that is based on day-night average sound level or total day-night sound exposure. Sounds, such as from highway traffic, are evaluated directly by sound exposure or sound level without adjustment. The prediction method is directly analogous to the use of day-night average sound level to predict the response of a community to general environmental sounds.

1.3 This Standard does not address the effects of short-term exposure of people to intrusive sounds in locations such as parks and wilderness areas. The Standard also does not address other effects of noise such as sleep disturbance or health effects. This Standard does not provide a method to predict the response of a community to short-term, infrequent, non-repetitive sources of sound.

1.4 This Standard introduces the application of new descriptors: adjusted sound exposure and adjusted sound exposure level. The new descriptors are closely related to sound exposure and sound exposure level, respectively. The new descriptors are introduced to facilitate the prediction of the response of communities to the wide range of outdoor sounds covered by the scope of the Standard.

1.5 The sounds are assessed either singly or in combination, allowing for consideration, when necessary, of the special characteristics of impulsiveness, tonality, onset rate, and low-frequency content. In the same manner as sound exposure and sound exposure level are used to generate total day-night sound exposure or total day-night average sound level, adjusted sound exposure or adjusted sound exposure level are used to generate adjusted total day-night sound exposure or adjusted day-night average sound level.

1.6 Annoyance is not the only possible measure of community response. One frequently cited measure is numbers of complaints, sometimes normalized to numbers of inhabitants. Complaints can be particularly relevant near factories and plants, by airports and military installations, etc. Complaints do not correlate well with long-term average metrics such as DNL (see Refs. 7 and 8 for example). Unfortunately, in general, metrics to predict the likelihood and prevalence of complaints do not yet exist with sufficient accuracy. One notable exception is the high-energy impulse sound generated by military activities and similar civilian noise sources, and informative Annex G provides procedures for assessing the risk of noise complaints from such sources.

1.7 The addition of adjustments eliminates the possibility to measure the total adjusted sound exposure or sound exposure level in a general situation that comprises a variety of sound sources (e.g., the combination of a highway leading to an airport and the airport itself). As a possible measurable alternative, this Standard introduces a new metric based on the equal-loudness level contours that were contained in ISO 226:1987. This new method uses the equal-loudness level contours as a set of dynamic filters that vary both with amplitude and frequency. This method is described in informative Annex H.

2 Normative references

The following referenced documents are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

[1] ANSI S1.1-1994 (R 2004) *American National Standard Acoustical Terminology.*

[2] ANSI S12.9-1988/Part 1 (R 2003) *American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound - Part 1.*

[3] ANSI S12.9-1992/Part 2 (R 2003) *American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound - Part 2: Measurement of Long-Term Wide-Area Sound.*

[4] ANSI S12.9-1993/Part 3 (R 2003) *American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound - Part 3: Short-term Measurements with an Observer Present.*

[5] ANSI S12.9-1998/Part 5 (R 2003) *American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound - Part 5: Sound Level Descriptors for Determination of Compatible Land Use.*

[6] ANSI S1.13-2005 *American National Standard Methods for the Measurement of Sound Pressure Levels in Air.*

3 Terms and definitions

For the purposes of this standard, the terms and definitions given in ANSI S1.1-1994 and the following apply:

3.1(a) adjusted sound exposure. Frequency-weighted sound exposure adjusted for the change in annoyance caused by certain impulsive sounds, the presence of prominent discrete-frequency tones, sounds that startle because of their rapid onset rate, sounds with strong low-frequency content, and the presence of masking background sound. Unit, pascal-squared second (Pa^2s); symbol, N.

NOTE 1 Adjustments and frequency weightings for various types of sounds are given in Clause 7.

NOTE 2 The unit of pascal-squared second for adjusted sound exposure has been abbreviated as "pasque."

3.1(b) reference sound exposure. The product of the square of the reference sound pressure of 20 μPa and the reference time of 1 s. Unit, pascal-squared second (Pa^2s); symbol, E_0.

3.1(c) adjusted sound exposure level. Ten times the base-10 logarithm of the ratio of the adjusted sound exposure to the reference sound exposure E_0. Unit, decibel (dB); symbol, L_{NE}.

3.2 adjusted total day-night sound exposure. Frequency-weighted sound exposure for a 24-hour day calculated by adding adjusted sound exposure obtained during the daytime (0700-2200 hours) to ten times adjusted sound exposure obtained during the nighttime (0000-0700 and 2200-2400 hours). Unit, pascal-squared second (Pa^2s); symbol, N_{dn}.

3.3(a) adjusted day-night average sound pressure. Square root of ratio of adjusted total day-night sound exposure to 86,400 s. Unit, pascals (Pa).

3.3(b) adjusted day-night average sound level. Ten times the base-10 logarithm of the ratio of the square of the adjusted day-night average sound pressure to the square of the reference sound pressure of 20 μPa. Unit, decibel (dB); symbol, L_{Ndn}.

3.4 impulsive sound. Sound characterized by brief excursions of sound pressure (acoustic impulses) that significantly exceed the ambient environmental sound pressure. The duration of a single impulsive sound is usually less than one second.

NOTE At the time of publication, no mathematical descriptor existed to unequivocally define the presence of impulsive sound or to separate impulsive sounds into categories.

3.4.1 highly impulsive sound. Sound from one of the following enumerated categories of sound sources: small-arms gunfire, metal hammering, wood hammering, drop hammering, pile driving, drop forging, pneumatic hammering, pavement breaking, metal impacts during rail-yard shunting operation, and riveting.

3.4.2 high-energy impulsive sound. Sound from one of the following enumerated categories of sound sources: quarry and mining explosions, sonic booms, demolition and industrial processes that use high explosives, military ordnance (e.g., armor, artillery and mortar fire, and bombs), explosive ignition of rockets and missiles, explosive industrial circuit breakers, and any other explosive source where the equivalent mass of dynamite exceeds 25 g. Normally, for single impulsive sounds of concern for this Standard, the A-weighted sound exposure level will exceed 65 dB and the C-weighted sound exposure level will exceed 85 dB.

3.4.3 regular impulsive sound. Impulsive sound that is not highly impulsive sound or high-energy impulsive sound.

3.5 onset rate. Nominally, the average rate of change of sound level during the onset of a noise event. Mathematically, onset rate is the rate of change of the A-weighted event sound level between the time the event sound level first exceeds the ambient sound level by 10 dB, and the time the event sound level first exceeds a level that is 10 dB less than the event's maximum fast-time-weighted sound level. Onset rate is defined for those event sound levels for which the maximum A-frequency-weighted, fast-time-weighted sound level exceeds the ambient sound level by at least 30 dB. Unit, decibels per second (dB/s).

NOTE 1 The nominal 125-ms time constant of fast time weighting normally is not small enough to accurately determine onset rate. Onset rate should be determined from the time variation of the level of the squared sound pressure. A digital system that provides a series of short-time-average sound levels may be used. In this case, the averaging time for each sound level in the series should be no greater than 1/10 and no less than 1/25 of the time span over which the onset rate is determined. A digital or analog system with exponential time weighting also may be used. In this case, the exponential time constant should be no greater than 1/4 and no less than 1/10 of the time span over which the onset rate is determined.

NOTE 2 A determination of onset rate should not be unduly influenced by anomalous fluctuations in the sound level.

3.6 time above. The time per stated unit time interval that the sound pressure level exceeds a criterion level (e.g., 30 s per hour). The frequency weighting or filtering (e.g., A-weighting), time weighting or integration time interval, and the unit time interval all must be stated. Typical Units: seconds (s) or minutes.

4 Descriptors for environmental sounds

4.1 Single-event sounds

4.1.1 Descriptors

Sounds from single events such as the passby of a truck, the flyby of an airplane, or an explosion at a quarry are all examples of single-event sounds. Each sound can be characterized by many descriptors. These descriptors include physical quantities and the corresponding levels in decibels. The level of a descriptor and its corresponding physical quantity form a descriptor pair. Three descriptor pairs often are used to describe the sound of single events. For each of these, frequency-weighting A is understood except for high-amplitude impulsive sounds or sounds with strong low-frequency content. The preferred three descriptor pairs are:

peak (frequency-weighted) sound pressure and peak (frequency-weighted) sound pressure level;

maximum exponential-time-weighted sound pressure and maximum sound level; and

sound exposure and sound exposure level.

NOTE 1 For the above descriptor pairs, the frequency weighting should be specified if frequency-weighting A is not employed, e.g., as peak C-weighted sound pressure level, C-weighted sound exposure level.

NOTE 2 For maximum sound pressure (and maximum sound level), the exponential-time-weighting should be specified, e.g., as fast (F) or slow (S).

4.1.2 Event duration

Event duration shall be specified relative to some characteristic of the sound such as the time of occurrence of the maximum sound level or the time some threshold was exceeded. For example, duration may be the total time that the sound level is within 10 dB of the maximum sound level.

4.2 Continuous sounds

Environmental sounds from sources such as transformers, fans, or cooling towers are examples of continuous sounds. Amplitudes of continuous sounds may be constant or slowly varying. Each sound can be characterized by many descriptors. Two descriptor pairs are commonly used to describe a continuous sound. For each of these, frequency-weighting A is commonly used. The two preferred descriptor pairs are:

maximum (exponential-time-weighted) sound and maximum sound level; and

time-average sound pressure and time-average (equivalent-continuous) sound level.

NOTE 1 For both of the above descriptors, the frequency weighting should be specified if frequency-weighting A is not employed.

NOTE 2 For maximum (exponential-time-weighted) sound (and maximum sound level), the exponential-time weighting should be specified, e.g., as fast (F) or slow (S).

NOTE 3 See Clauses 5.1.4, 5.1.5, and 5.1.6 in ANSI S12.9-1988/Part 1 (R2003) for definitions of these quantities.

4.3 Repetitive single-event sounds

Repetitive single-event environmental sounds typically are recurrences of single-event sounds. For example, during a day, the sound from traffic on a highway is the sum of the sound from multiple individual vehicle passbys. In this Standard, all repetitive single-event sounds utilize the descriptor for the particular single-event sounds and the corresponding number of events.

5 Sound measurement locations

All sounds, except high-energy impulsive sounds, shall be measured or predicted as if they had been measured by a microphone outdoors, over acoustically absorptive ground (grass), at a height of approximately 1.2 m and with no nearby reflecting surfaces except the ground. Alternative microphone locations may be used, but their acoustical characteristics shall be specified. An example of an alternative location is outside an open, upper-story window in a high-rise apartment building where the purpose is to predict or assess the environmental sound at that location. High-energy impulsive sounds shall be measured or predicted as if they had been measured by a microphone within 50 mm of a hard reflecting surface (e.g., a building wall, roof, or ground plane, as appropriate).

NOTE 1 A reflecting surface is required because sonic booms, which are one form of high-energy impulsive sounds, have traditionally been measured or predicted for a location on a reflecting ground plane or structure.

NOTE 2 To ensure comparable data, sonic booms should be measured on a reflecting ground plane or other equivalent structure.

6 Adjustments for background sound

6.1 General

Annex A discusses a general method to include adjustments for background sound. The general method is applicable to three cases: (1) the sound of concern is very noticeable and detectable in the background setting of interest, (2) the sound of concern is virtually unnoticeable and undetectable in the background setting of interest, and (3) the sound of concern is in a range such that it may be noticeable and detectable only for a portion of the time.

6.2 Specific requirements

When the conditions of 6.1(2) apply and the sound is virtually unnoticeable and undetectable in the background setting of interest, then its sound exposure shall not be included in a calculation of the total sound exposure from multiple sound sources. If some particular sound is excluded, then the physical background setting shall be specified. For example, this setting may be "urban residential not near an arterial street, outdoors," or "suburban residential indoors with windows partially open," or "urban residential near an arterial street, indoors with windows closed."

NOTE Direct measurements may be used to determine the background sound level prevailing for the environment. Procedures in Part 3 of ANSI S12.9 should be used to measure the background sound level.

Alternatively, the nominal background sound levels given in Part 3 of ANSI S12.9 may be used for various urban environments.

7 Method to assess environmental sounds either singly or in combination

This Standard permits assessment of environmental sounds from individual sources or any combination of sources. If the sound has special characteristics or unusual community response, then adjusted sound exposure or adjusted sound exposure level shall be used to describe the source(s) of sound. In addition, the total adjusted sound environment shall include a weekend daytime adjustment, and is used to predict long-term community response.

7.1 General environmental sounds

General environmental sounds are assessed using frequency-weighting A. (Environmental sounds with special characteristics are described in 7.2.) Sound exposure, sound exposure level, total time-period sound exposure, time-average sound level, total day-night sound exposure, and day-night average sound level are the preferred descriptors. The exposure method of presentation is described in 7.1.1, the left-hand column below. The level method of presentation is described in 7.1.2, the right-hand column below.

7.1.1 Exposure method	**7.1.2 Level method**
7.1.1.1 Sound exposure Sound exposure is a descriptor for characterizing the sound from individual acoustical events. For individual single-event sounds such as vehicle passbys, sound exposure may be directly measured or predicted for the sound-producing events under consideration. For a continuous source, the total time-period sound exposure may be measured or predicted for the time period of interest. A-weighted sound exposure E_A, in pascal-squared seconds, may be calculated as the product of the time-mean-squared, A-weighted sound pressure $\overline{p_A^2}$ in pascals squared and the duration, in seconds, of the time period of interest T, i.e., as $E_A = \overline{p_A^2} T$. (1a)	**7.1.2.1 Sound exposure level** Sound exposure level is a descriptor for characterizing the sound from individual acoustical events. For individual single-event sounds such as vehicle passbys, sound exposure level may be directly measured or predicted for the sound-producing events under consideration. For a continuous source, the sound exposure level may be measured or predicted for the time period of interest. A-weighted sound exposure level L_{AE}, in decibels, may be calculated as ten times the base-10 logarithm of the ratio of the A-weighted sound exposure E_A to the reference sound exposure E_0 defined in 3.1(b), i.e., as $L_{AE} = 10 \lg (E_A/E_0)$. (1b)

7.1.1.2 Total sound exposure

Total sound exposure may be used to characterize the sound of one or more events from individual or combined sources of sound during a time period of interest such as the hour from 1600 to 1700, daytime from 0700 to 2200, or nighttime from 2200 to 2400 and 0000 to 0700. Total A-weighted sound exposure in a time period $E_{A(period)}$, in pascal-squared seconds, is the sum of the N sound exposures E_{Ai} from the i-th individual single-event sounds during the stated time period.

In mathematical notation,

$$E_{A(period)} = \sum_{i=1}^{N} E_{A\,i} \,. \qquad (2a)$$

NOTE The stated time period may be of any duration such as one daytime period for one day or for any number of days up to 365 days of a year. Furthermore, the sound exposure E_{Ai} for the i-th event may be for any one sound source or a combination of sources.

7.1.2.2 Time-average sound level

Time-average sound level may be used to characterize the sound of one or more events from individual or combined sources of sound during a time period of interest such as the hour from 1600 to 1700, daytime from 0700 to 2200, or nighttime from 0000 to 0700 and 2200 to 2400. Time-average, A-weighted sound level $L_{A(period)}$, in decibels, is calculated from the total sound exposure in the period.

In mathematical notation,

$$L_{A(period)} = 10\lg\left[(T_0 / T) \sum_{i=1}^{I} 10^{0.1 L_{AEi}}\right], \qquad (2b)$$

where T_0 is the reference time of 1 s and T is the total time period in seconds for the duration of the time average.

NOTE For a constant time-average sound level of 60 dB, sound exposure level $L_{AE(period)}$ and sound exposure $E_{A(period)}$ are related as shown in Table 1 for selected integration time periods T.

7.1.1.3 Total day-night sound exposure

Total day-night sound exposure is a descriptor for characterizing long-term acoustical environments from sounds of one or more events from individual or combined sound sources. Total day-night sound exposure E_{Adn}, in pascal-squared seconds, is the sum of daytime sound exposures plus 10 times the sum of nighttime sound exposures where daytime is the 15 hours from 0700 to 2200 and nighttime is the nine hours from 0000 to 0700 and from 2200 to 2400 in any 24-hour day.

In mathematical notation,

$$E_{Adn} = \sum_{i=1}^{N_d} E_{Ai} + 10 \sum_{i=1}^{N_n} E_{Ai} \,, \qquad (3a)$$
$$= E_{Ad} + 10 E_{An} \,,$$

where N_d is the number of daytime sound exposures and N_n is the number of nighttime sound exposures.

7.1.2.3 Day-night average sound level

Day-night average sound level is a descriptor for characterizing long-term acoustical environments from sounds of one or more events from individual or combined sound sources. Day-night average sound level, in decibels, is calculated from ten times the base-10 logarithm of the sum of the daytime sound exposures plus the nighttime sound exposures, where sound exposure levels or sound levels occurring during nighttime hours are weighted by 10 dB.

In mathematical notation,

$$L_{dn} = 10\lg\left[(15/24)(T_0 / T_d) \sum_{i=1}^{N_d} 10^{0.1 L_{AEi}}\right] + 10\lg\left[(9/24)(T_0 / T_n) \sum_{i=1}^{N_n} 10^{0.1(L_{AEi} + 10)}\right] \qquad (3b)$$

$$= 10\lg\left[(15/24)10^{0.1 L_d} + (9/24)10^{0.1(L_n + 10)}\right]$$

where T_d = the 15 daytime hours or 54,000 s and T_n = the 9 nighttime hours or 32,400 s.

Table 1 — Relation between sound exposure level and sound exposure for a constant sound level of 60 dB.

T	$L_{AE(period)}$ (dB)	$E_{A(period)}$ (Pa^{2}s)	T	$L_{AE(period)}$ (dB)	$E_{A(period)}$ (Pa^{2}s)
1 s	60.0	0.0004	1 h	95.6	1.44
1 min	77.8	0.024	24 h	109.4	34.6

NOTE A day-night sound exposure of 10 Pa^{2}s corresponds to a nominal day-night average sound level of 55 dB. A day night average sound level of 65 dB corresponds to a nominal total day-night sound exposure of 100 Pa^{2}s.

7.2 Adjustments to general environmental sound

Research has shown that frequency-weighting A, alone, is not sufficient to assess sounds characterized by tonality, impulsiveness, very fast onset rates, or strong low-frequency content. Also, research has shown that frequency-weighting A, alone, under-predicts the community response to aircraft noise and to weekend daytime noise. To predict the long-term response of a community to sounds with some of those special characteristics, sources, or times of occurrence, an adjustment factor is used to multiply the sound exposure or an adjustment in decibels is added to the A-weighted sound exposure level. Annex H contains a bibliography of reports and articles describing the technical basis of the assessment and prediction methods of this Part 4.

Sound exposure and sound exposure level as discussed in 7.1.1.1 and 7.1.2.1 are descriptors for characterizing the environmental sound from individual acoustical events. Frequency weighting A is used for all sound sources except (1) high-energy impulsive sounds for which frequency-weighting C is used, and (2) sounds with strong low-frequency content. Adjusted sound exposure is the quantity used in this Standard to assess sounds without and with special characteristics with respect to the potential community response. For general environmental sounds without special characteristics (i.e., sounds assessed by the method of 7.1), adjusted sound exposure is numerically equal to A-weighted sound exposure.

For sounds with special characteristics, sources, or times of occurrence, the calculation of adjusted sound exposure or adjusted sound exposure level is performed as described below. The adjusted exposure method of presentation is described in 7.2.1, the left-hand column below. The adjusted level method of presentation is described in 7.2.2, the right-hand column below.

7.2.1 Adjusted exposure method

7.2.1.1 Adjusted sound exposure

For any sound except high-energy impulsive sound or sounds having strong low-frequency content, adjusted sound exposure N_j is given by the sound exposure E_i for the i-th single-event sound multiplied by the adjustment factor K_j for the j-th type of sound, as given in Table 2.

In mathematical notation,

$$N_j = K_j E_i. \tag{4a}$$

7.2.2 Adjusted level method

7.2.2.1 Adjusted sound exposure level

For any sound except high-energy impulsive sound or sounds having strong low-frequency content, adjusted sound exposure level L_{Nj} is given by the sound exposure level L_{Ei} for the i-th single-event sound plus the level adjustment $\overline{K}_j$ for the j-th type of sound, as given in Table 2.

In mathematical notation,

$$L_{Nj} = L_{Ei} + \overline{K_j}. \tag{4b}$$

Equations to convert between adjusted sound exposure, in pascal-squared seconds, and adjusted sound exposure level, in decibels, are:

$$L_{Nj} = 10\lg(N_j / p_0^2 T_0) = 10\lg(N_j / T_0) + 94 \quad (5a)$$

$$N_j = (T_0)10^{0.1(L_{Nj} - 94)}, \quad (5b)$$

where $-10\lg(p_0^2) = 94$ dB and T_0 is the reference time of 1 s.

7.2.1.2 Adjusted total sound exposure

During a time period of interest such as daytime, the adjusted total sound exposure $N_{(\text{period})}$, in pascal-squared seconds, is the sum of the adjusted sound exposures N_{ij} from each individual event i of I events, for each source of sound j of J sources during the stated time period.

In mathematical notation,

$$N_{(\text{period})} = \sum_{i=1}^{I} \sum_{j=1}^{J} N_{ij}\,. \quad (6a)$$

The stated time period may be of any duration such as one daytime period for one day or for any number of days up to 365 days of a year. Furthermore, the adjusted sound exposure N_{ij} for the i-th event may be for any one source j or a combination of sources.

In equation (6a), sounds without special characteristics are included with an adjustment factor of 1 as shown in Table 2.

7.2.2.2 Adjusted time-average sound level

During a time period of interest such as daytime, the adjusted time-average sound level $L_{N(\text{period})}$, in decibels, is calculated from the adjusted sound exposure levels L_{Nij} from each individual event i of I events, for each source of sound j of J sources during the stated time period.

In mathematical notation,

$$L_{N(\text{period})} = 10\lg\left[(T_0 / T)\sum_{i=1}^{I} \sum_{j=1}^{J} 10^{0.1 L_{Nij}}\right]. \quad (6b)$$

The stated time period T, in seconds, may be of any duration such as one daytime period for one day or for any number of days up to 365 days of a year. Furthermore, the adjusted sound exposure level L_{Nij} for the i-th event may be for any one source j or a combination of sources.

In equation (6b), sounds without special characteristics are included with a level adjustment of 0 as shown in Table 2.

For an averaging time period T in seconds, equations to convert adjusted total sound exposure in pascal-squared seconds and adjusted time-average sound level in decibels are:

$$L_{N(\text{period})} = 10\lg(N_{(\text{period})} / p_0^2 T_0) - 10\lg(T / T_0) = 10\lg(N_{(\text{period})} / T) + 94 \quad (7a)$$

$$N_{(\text{period})} = (T)10^{0.1(L_{N(\text{period})} - 94)} \quad (7b)$$

7.2.1.3 Adjusted total day-night sound exposure	**7.2.2.3 Adjusted day-night average sound level**
Adjusted total day-night sound exposure is similar to total day-night sound exposure, but includes the adjustment factors described in Table 2. Adjusted nighttime sound exposures are weighted by a factor of 10. The mathematical formulation of adjusted total day-night sound exposure N_{dn} is similar to that for total day-night sound exposure described in 7.1.1.3.	Adjusted day-night average sound level is similar to day-night average sound level, but includes the level adjustments described in Table 2. Ten decibels are added to adjusted nighttime sound exposure levels. The mathematical formulation of adjusted day-night average sound level L_{Ndn} is similar to that for day-night average sound level described in 7.1.2.3.

For a time period T_{dn} of 24 h or 86,400 s, equations to convert adjusted day-night average sound level L_{Ndn} in decibels and adjusted total day-night sound exposure N_{dn} in pascal-squared seconds are:

$$L_{Ndn} = 10\lg(N_{dn} / p_0^2 T_0) - 10\lg(T_{dn} / T_0) = 10\lg(N_{dn} / T_0) + 44.6 \qquad (8a)$$

$$N_{dn} = (T_0)10^{0.1(L_{Ndn} - 44.6)}, \qquad (8b)$$

where $-10\lg(p_0^2) - 10\lg(T_{dn}/T_0) = 94 - 49.4 = 44.6$ dB, and $T_0 = 1$ s.

Table 2 — Adjustment factors and level adjustments for assessment of all types of environmental sounds.

Sound source		K_j		$\bar{K}_j = 10\lg(K_j)$	
Factor	Type	Symbol	Value	(dB)	Condition
without special characteristics	general broadband sound (e.g., road traffic)	K	1	0	…
Special characteristics	regular impulsive	K_I	3	5	…
	highly impulsive	K_I	16	12	…
	high-energy impulsive				see Annex B
	rapid onset rate R	K_R	1	0	R < 15 dB/s
		K_R	$10^{1.1\lg(R/15)}$	11 lg(R/15)	15 ≤ R < 150 dB/s
		K_R	12.6	11	R ≥ 150 dB/s
	tonal	K_t	3	5	see Annex C
	strong low-frequency content				see Annex D
Sources	aircraft	K_A	1	0	DNL<55
		K_A	10*lg(DNL-55)	DNL-55	55<DNL<60
		K_A	3	5	DNL≥60
Time of Day	nighttime	K_N	10	10	
Day of the Week	weekends, daytime	K_W	3	5	

NOTE 1 If more than one special characteristic adjustment applies to a given single sound source such as a fan, only the largest adjustment shall be applied. Time-of-day and day-of-the-week adjustments are always included in addition to other adjustments, if any.

NOTE 2 Each adjusted sound exposure N_{ij} is calculated from its corresponding sound exposure level L_{AEij} and adjustment factor K_j according to

$$N_{ij} = (K_j)[(T_0)(10^{0.1(L_{AEij}-94)})]. \quad (9)$$

NOTE 3 Each adjusted sound exposure level L_{Nij} is calculated from its corresponding sound exposure level and level adjustment $\bar{K}_j$ according to

$$L_{Nij} = L_{AEij} + \bar{K}_j. \quad (10)$$

NOTE 4 If sounds are not audible at the location of interest, then the concepts of Clause 6 apply and the adjusted sound exposure for those sounds shall not be included in the total.

NOTE 5 The assessment method for essentially continuous sounds with strong low-frequency content shall not be applied unless the time-average C-weighted sound level exceeds the A-weighted sound level by at least 10 dB.

NOTE 6 Normally, the onset rate is measured. Annex E provides an approximate method to calculate the onset rate for low-flying airplanes.

NOTE 7 If highly impulsive sounds occur at a rate greater than about 20 per second, then the sounds usually are not perceived as distinct impulses and no adjustment shall be applied. If the rate is regular and greater than 30 per second, then a tone will be perceived and a tonal adjustment may be required. If the rate is irregular and greater than 20 per second, then the highly impulsive sounds will appear to merge into a broadband noise-like sound and no adjustment shall be applied.

8 Reporting assessments of environmental sounds and prediction of long-term community annoyance response

8.1 Use of A-weighted sound exposure and day-night average sound level

If the acoustical environment includes only sounds having no special characteristics, then adjusted sound exposure is numerically equal to the sound exposure. All reporting then shall be in terms of A-weighted day-night average sound level or A-weighted sound exposure. If the acoustical environment includes any combination of sounds having special characteristics, then the numerical description of the total acoustical environment shall be reported in terms of adjusted sound exposure or adjusted sound exposure level. This procedure is required because adjusted sound exposure and adjusted sound exposure level are not measured quantities.

8.2 Assessment of environmental sounds

A measurement or calculation of the (adjusted) total sound exposure or time-average sound level shall be used to assess environmental sounds.

To predict or measure the (adjusted) total sound exposure or time-average sound level during a time period of interest, (adjusted) sound exposures shall be summed over the duration of the stated time period, typically, for some hour of the day, all day, all night, or a combination of the day-night sound or (adjusted) day-night sound exposure.

For example, for an airport, factory, or highway, one might measure or calculate the annual average total day-night sound exposure or annual average adjusted total day-night sound exposure on an average day by summing the total sound exposure or adjusted total sound exposure throughout the year using equations (1a) or (6a), respectively, and then dividing by 365.

NOTE The user of this Standard can employ these methods for shorter periods of time, but they should report this change and not attempt to predict percent highly annoyed using Clause 8.3 or Annex F, since the Annex F data all represent long-term situations

8.3 Prediction of long-term annoyance response of communities

Annual average (adjusted) total day-night sound exposure or annual average (adjusted) day-night average sound level is needed to predict the long-term annoyance response of a community.

Table F.1 in Annex F may be used to predict the percentage of a population that is likely to be highly annoyed by the environmental sound with that annual average (adjusted) total day-night sound exposure or that annual average (adjusted) day-night average sound level.

8.4 Reporting

Reporting shall include the following:

a) the stated time period (e.g., daytime, 1600 to 1700 hours);

b) the day or days included in the time average;

c) the adjusted time-period total sound exposure or adjusted time-period time-average sound level;

d) a description of the sound source or sources included in the total time period;

e) a description of the measurement or prediction site;

f) a description of any procedures used in accordance with Clause 7 and Annex A to correct for contamination by background sound and a description of the background sound; and

g) the results of the prediction of long-term annoyance response of the community.

NOTE The stated time period may be for any duration such as one daytime period for one day or for any number of days up to 365 days of a year. Furthermore, the sound exposure or adjusted sound exposure, E_{Aj} or N_j, for the j-th source, may be for any one source or a combination of sources.

Annex A

(informative)

Adjustments for background sound

A.1 Introduction

A.1.1 General

Analysis of the annoyance generated by any given source of community noise is usually based on the assumption that the given source is the primary source of noise, and that the annoyance is not influenced by the presence (or absence) of sounds from other sources. For example, airports or roadways are often assessed as if they were the only source of sound.

Because there almost always is noise from more than one source, two questions arise:

1) When does the amplitude of the sound from other sources become sufficient in magnitude to modify the annoyance generated by the source under evaluation?

2) Under what circumstances does the presence of sound from one source alter the annoyance caused by another source?

A.1.2 Background sound

Background noise is defined in ANSI S1.1 as "the total of all sources of interference in a system used for the production, detection, measurement, or recording of a signal, independent of the presence of the signal." For the purposes of this annex, background sound is the total of all sounds produced by sources other than the one for which the annoyance response is being evaluated. The amplitude of the background sound can be continuous or time-varying. Background sound may be produced by a variety of sources.

A.1.3 Background sound situations

There are at least two situations when background sound may influence or alter the presumed relation between annoyance and a physical measure of the sound for a given type of noise:

1) Masking is present when the threshold of detection of one sound is raised by the presence of another (masking) sound. Masking may be of varying degree, with complete masking resulting in the inaudibility (and resulting absence of annoyance) of the sound signal under evaluation. Given the time varying nature of many community sounds and their differences in spectral composition, the degree of masking is difficult to determine in most situations unless the differences between the time-average sound levels of the different sources are at least 20 dB.

NOTE A masking analysis requires comparison of sound pressure levels in different frequency bands. Sounds having similar A-weighted sound levels may have quite different spectral content. Hence, it is impossible to determine the degree of masking from A-weighted sound levels.

2) The presence of sound from one source may alter an evaluation of the annoyance of the sound from another source. For example, at an outdoor music concert, one might be mildly annoyed by the noise from an aircraft flyover occurring during an intermission, but be highly annoyed by a similar

noise intrusion during the musical performance, even though the background sound levels during the intermission and performance are the same.

Alternatively, one might ask whether the presence of intrusive sounds from one source alters the annoyance resulting from another intermittent sound, even though no masking of sounds may occur. (An example of this situation might be the evaluation of aircraft noise at a location exposed to noise from trains.)

NOTE The influence of interactions between sound sources, outlined in the alternative situation above, is usually difficult to determine or is unknown, and is ignored in the analysis given in this annex.

A.2 Mathematical development

A.2.1 Single-event sounds

For single-event sounds, N_{ij} is the adjusted sound exposure produced by a discrete event *i* and sound type *j*. K_{Bij} is the background sound adjustment factor for event *i* and sound type *j*. In the absence of noise from other sources, K_B equals 1. In the presence of noise from other sources K_B may vary from 1 to 0. With complete masking from other sources, $K_B = 0$.

Background sound adjustments are equivalent to changes in the noise adjustment factor K_B as a consequence of masking by other sound sources.

A.2.2 Continuous, or near-continuous, sounds and single-event sounds

For continuous, or near-continuous, sounds, time-average, A-weighted sound level is symbolized by L_{Acont} during the stated averaging time *T*.

Consider a situation where there are two sources of single-event sound [for example, (1) trains for which the adjusted sound exposures are N_{1i} and (2) aircraft for which the adjusted sound exposures are N_{2i}] and one source of continuous sound. The total adjusted sound exposure N_T for the three sources over time duration *T* is determined from

$$N_T = \sum_{i=1}^{I1} (N_{1i})(K_{B1i}) + \sum_{i=1}^{I2} (N_{2i})(K_{B2i}) + \left[10^{0.1(L_{Acont}-94)}\right](T)(K_{Bcont}). \quad (A.1)$$

NOTE 1 This 3-source example may be expanded to include any number of different sources of single-event or continuous sounds.

NOTE 2 I1 is the number of trains and I2 is the number of aircraft during time duration *T*.

For the situation where the single-event sounds for each source occurring during a time period of duration *T* are nearly equal (i.e., the sound exposure levels and maximum A-weighted sound levels are nearly equal), equation (A.1) is replaced by

$$N_T = (I1)(N_{1i})(K_{B1i}) + (I2)(N_{2i})(K_{B2i}) + \left[10^{0.1(L_{Acont}-94)}\right](T)(K_{Bcont}). \quad (A.2)$$

A.3 Background sound adjustment situations

There are three groups of situations where background sound adjustments may need to be considered.

A.3.1 Situations having little need for background sound adjustments

A.3.1.1 Maximum single-event sound level much greater than the sound level of the continuous sound source

When the maximum A-weighted sound levels of individual noise events from two sources are at least 15 dB greater than the time-average A-weighted sound level of the continuous sound source, and the number of individual noise events is not large (so that the probabilities of individual noise events from the two sources occurring at the same time are small), then there is little need for background sound adjustment to the sound exposures from the individual noise events. Hence, in this situation, background sound adjustment factors K_{B1i} and K_{B2i} in equations (A.1) and (A.2) remain equal to 1.0.

A.3.1.2 Few individual noise events

The impact of sound from individual sources on the background sound adjustment factor for continuous sound K_{Bcont} is negligible if there are only a few individual noise events from the sources. In this situation there is little likelihood of K_{Bcont} changing from a value of 1.

A.3.1.3 Many individual noise events

When there are many noise events from individual sound sources, separately or in combination, the total adjusted sound exposure from these sources is likely to be much larger than the sound exposure for the continuous noise. In this situation the contribution from the continuous sound source will have little effect on the total adjusted sound exposure.

A.3.2 Situations where background sound adjustments may be needed

A.3.2.1 Maximum single-event sound level nearly equal to the sound level of the continuous sound source

When the maximum A-weighted sound levels of individual single-event sounds from either of the two example sources, or both, are within 10 dB of the time-average A-weighted sound level, background sound adjustments K_{B1} and/or K_{B2} are needed because of partial masking. In this situation, a value of K_{B1} and/or K_{B2} equal to ½ may be appropriate.

A.3.2.2 Many individual noise events from either of both sound sources

When the maximum A-weighted sound levels of individual noise events from the two example sound sources are of the same order of magnitude and when the number of noise events from one or both sources is large, background sound adjustments K_{B1} or K_{B2}, or both, are needed because of partial masking of one individual noise event by another. In this situation, a value of K_{B1} and/or K_{B2} equal to ½ may be appropriate.

A.3.3 Situations where significant background sound adjustments are needed

When the maximum A-weighted sound levels of individual noise events are at least 10 dB less than the time-average A-weighted sound level for the continuous sound, partial or complete masking of the sound from the individual events is likely to occur. In this situation, a value of zero for the background sound adjustments of K_{B1} and K_{B2} is recommended.

A.3.4 Guidance on the development of background sound adjustment factors

Appropriate background sound adjustment factors may be developed from considerations of the level of the A-weighted signal-to-noise ratio β equal to (S+N)/N, i.e., the combined level of the A-weighted signal plus the A-weighted noise, minus the level of the A-weighted noise.

In situations where the spectra of the sounds from the sound sources are vastly different, the levels of signal-to-noise ratios determined from octave- or one-third-octave-band sound pressure levels should be examined instead of A-weighted sound levels to establish background sound adjustment factors K_{Bjk} for each *j*-th source and spectral band *k*. These spectral signal-to-noise levels are then examined to determine how the sound exposures in question should be combined in the calculation of total sound exposure.

Recommended values for K_{Bjk} are:

$$K_{Bjk} = 1, \text{ for } \beta \geq 20 \text{ dB} \tag{A.3}$$

$$K_{Bjk} = \beta / 20, \text{ for } 0 < \beta \leq 20 \text{ dB} \tag{A.4}$$

$$K_{Bjk} = 0, \text{ for } \beta = 0 . \tag{A.5}$$

Annex B

(normative)

High-energy impulsive sounds

B.1 Introduction

The procedure in this annex is based on a 1996 study by the National Research Council, Committee on Hearing, Bioacoustics, and Biomechanics (CHABA); see Ref. 14. It conforms with ISO 1996:1-2003 (Ref. 6) which is also based, in part, on the CHABA study.

NOTE The CHABA study presented two methods to assess high-energy impulsive sounds. One method is amenable to the concept of adjusted sound exposure and is presented in this annex. The other method is not amenable to the concept of adjusted sound exposure.

B.2 Fundamental descriptor

For single-event, high-energy impulsive environmental sounds, the fundamental descriptor is C-weighted sound exposure E_C or C-weighted sound exposure level L_{CE}.

B.3 Measurement

C-weighted sound exposure (or C-weighted sound exposure level) shall be measured or predicted as if it had been measured by a microphone in a "free-field" and at least 15 m from any large reflecting object other than the ground which should be grass or a field.

B.4 Calculation of adjusted sound exposure level for high-energy impulsive sounds from C-weighted sound exposure level

For each single event, adjusted sound exposure level L_{NE} for high-energy impulsive sounds shall be calculated from the C-weighted sound exposure level L_{CE} according to

$$L_{NE} = 2\ L_{CE} - 93 \text{ dB for } L_{CE} \geq 100 \text{ dB} \qquad \text{(B.1)}$$

$$L_{NE} = 1.18\ L_{CE} - 11 \text{ dB for } L_{CE} < 100 \text{ dB}$$

The two relations intersect at a C-weighted sound exposure level of 100 dB.

B.5 Calculation of adjusted sound exposure level from C-weighted sound exposure level

Adjusted sound exposure N for high-energy impulsive sounds is related to adjusted sound exposure level L_{NE} according to

$$N = 10^{0.1(L_{NE} - 94)}. \qquad \text{(B.2)}$$

Substituting equation (B.1) in equation (B.2) yields

$$N = 10^{0.1(2L_{CE} - 93 - 94)} = 10^{0.1(2L_{CE} - 187)} \quad \text{(B.3a)}$$

for $L_{CE} \geq 100$.

$$N = 10^{0.1(1.18L_{CE} - 11 - 94)} = 10^{0.1(1.18L_{CE} - 105)} \quad \text{(B.3b)}$$

for $L_{CE} \leq 100$.

B.6 Calculation of adjusted sound exposure level from C-weighted sound exposure

C-weighted sound exposure level L_{CE} is related to C-weighted sound exposure E_C by

$$L_{CE} = 94 + 10 \lg(E_C / 1). \quad \text{(B.4)}$$

Substituting equation (B.4) in equation (B.3) yields the relation between adjusted sound exposure N and C-weighted sound exposure E_C for high-energy impulsive sounds as

$$\begin{aligned} N &= 10^{0.1\{2[94 + 10 \lg(E_C/1)] - 187\}} \\ &= 10^{[\lg(E_C/1)^2 + 0.1]} \\ &= (E_C)^2(10^{+0.1}) \\ &= 1.2589(E_C)^2 \end{aligned} \quad \text{(B.5a)}$$

for $E_C \geq 3.9811$.

$$\begin{aligned} N &= 10^{0.1\{1.18[94 + 10 \lg(E_C/1)] - 105\}} \\ &= 10^{[\lg(E_C/1)^{1.18} + 0.592]} \\ &= (E_C)^{1.18}(10^{+0.592}) \\ &= 3.908(E_C)^{1.18} \end{aligned} \quad \text{(B.5b)}$$

for $E_C < 3.9811$.

B.7 Use of adjusted sound exposure

Adjusted sound exposures determined by the procedures in B.4, B.5, or B.6 are used in equation (6a) to provide the contributions from high-energy impulsive sounds to the total adjusted sound exposure.

Annex C

(informative)

Sounds with tonal content

The test for the presence of a prominent discrete-frequency spectral component (tone) typically compares the time-average sound pressure level in some one-third-octave band with the time-average sound pressure levels in the adjacent two one-third-octave bands. For a prominent discrete tone to be identified as present, the time-average sound pressure level in the one-third-octave band of interest is required to exceed the time-average sound pressure level for the two adjacent one-third-octave band by some constant level difference.

The constant level difference may vary with frequency. Possible choices for the level differences are: 15 dB in low-frequency one-third-octave bands (25-125 Hz), 8 dB in middle-frequency bands (160-400 Hz), and 5 dB in high-frequency bands (500-10,000 Hz).

NOTE 1 The above guidance is from Annex C of Part 3 of ANSI S12.9. Part 3 of ANSI S12.9 also contains guidance on the measurement of one-third-octave-band sound pressure levels.

NOTE 2 ANSI S1.13 Annex A presents more accurate methods for determining the presence of prominent discrete tones using narrow-band analysis.

Annex D

(informative)

Sounds with strong low-frequency content

D.1 Introduction

Sounds with strong low-frequency content engender greater annoyance than is predicted from the A-weighted sound level. The additional annoyance may result from a variety of factors including (1) less building sound transmission loss at low frequencies than at high frequencies and (2) increased growth in subjective loudness with changes in sound pressure level at low frequencies. In addition, environmental sound pressure levels in excess of 75 to 80 dB in the 16, 31.5, or 63-Hz octave bands may result in noticeable building rattle sounds. Rattle sounds can cause a large increase in annoyance. The methods in this annex may be used to assess environmental sounds with strong low-frequency content.

D.2 Analysis factors

Analysis of sounds with strong low-frequency content is based on the following three factors:

1) Generally, annoyance is minimal when octave-band sound pressure levels are less than 65 dB at 16, 31.5, and 63-Hz midband frequencies. However, low-frequency sound sources characterized by rapidly fluctuating amplitude, such as rhythm instruments for popular music, may cause annoyance when these octave-band sound pressure levels are less than 65 dB.

2) Annoyance grows quite rapidly with sound pressure level at very low frequencies. A "squared" function represents this phenomenon in this annex.

3) Annoyance to sounds with strong low-frequency content is virtually only an indoor problem.

Although windows and house walls have significant high-frequency sound transmission loss, sounds in the 16, 31.5 and 63-Hz octave bands pass through these structures to the interior with relative ease. The low-frequency sound pressure level within these structures is nearly equal to the outdoor sound pressure level because the minimal sound transmission loss of the windows and walls often is offset by modal resonance amplification in enclosed rooms.

D.3 Applicability

The procedures in this annex only should be applied to essentially continuous sounds with strong low-frequency content.

NOTE In accordance with NOTE 5 to Table 2, the adjustment factors for essentially continuous sounds with strong low-frequency content shall not be applied unless the time-average C-weighted sound level exceeds the A-weighted sound level by at least 10 dB.

D.4 Descriptor

The descriptor for sounds with strong low-frequency content is the summation of the time-mean-square sound pressures in the 16, 31.5, and 63-Hz octave bands. The result is the low-frequency, time-mean-square sound pressure p_{LF}^2. The corresponding low-frequency sound pressure level is symbolized by L_{LF}.

D.5 Adjusted sound exposures for sounds with strong low-frequency content

D.5.1 Adjusted sound exposure level from low-frequency sound pressure level

For sounds with strong low-frequency content, adjusted sound exposure level L_{NE} is calculated from low-frequency sound pressure level L_{LF} by

$$\begin{aligned} L_{NE} &= 2(L_{LF} - 65) + 55 + 10\lg(T/1) \\ &= 2L_{LF} - 75 + 10\lg(T/1) \end{aligned} \tag{D.1}$$

where T is the time duration of interest, in seconds, over which the low-frequency sound is present. The factor of 2 in equation (D.1) accounts for the rapid increase in annoyance with sound pressure level at low frequencies. Equation (D.1) also accounts for the additional annoyance from rattles that begins when the low-frequency sound pressure level exceeds 75 dB.

D.5.2 Adjusted sound exposure from low-frequency sound pressure level

For sounds with strong low-frequency content, adjusted sound exposure N is calculated from low-frequency sound pressure level L_{LF} by means of

$$\begin{aligned} N &= T[10^{0.1(2L_{LF}-75-94)}] \\ &= T[10^{0.1(2L_{LF}-169)}]. \end{aligned} \tag{D.2}$$

D.5.3 Adjusted sound exposure from low-frequency sound pressure

For sounds with strong low-frequency content, adjusted sound exposure N also may be calculated from the time-mean-square low-frequency sound pressure p_{LF}^2 by use of equation (D.2) as

$$\begin{aligned} N &= T[10^{0.1(2L_{LF}-169)}] \\ &= T[10^{0.1\{2[10\lg(p_{LF}^2/1)+94]-169\}}] \\ &= T[10^{0.1[10\lg(p_{LF}^4/1)+19]}] \\ &= (T)(p_{LF}^4)(10^{1.9}). \end{aligned} \tag{D.3}$$

D.6 Use of adjusted sound exposure

Adjusted sound exposures calculated by means of equations (D.2) or (D.3) are used in equation (6a) to provide the contributions to the total adjusted sound exposure from sounds with strong low-frequency content.

D.7 Noise-induced rattles

There is evidence that noise-induced rattles are very annoying and not accounted for by direct measurement of the audible sound. The evidence suggests that rattle annoyance may be independent of the number or duration of events. To prevent the likelihood of noise-induced rattles, the low-frequency sound pressure level should be less than 70 dB.

Annex E

(informative)

Onset rate for airplane flybys

Onset rate for the sound from a low-flying airplane may be estimated if the height of the airplane above ground, lateral offset of the calculation location from the nominal ground track, groundspeed, and the A-weighted sound exposure level of the airplane flyby are known.

The following equation provides an empirical estimate for use in Table 2 of the onset rate R in decibels per second for an airplane flying past some location.

$$\begin{aligned} R = 3.7 + \exp(&-1.1668 - 0.000563z \\ &-0.000177y + 0.0045v \\ &+0.02884L_{AE}) \end{aligned} \tag{E.1}$$

where

z = aircraft height above the elevation of the calculation location (metres);

y = lateral offset from the nominal aircraft track to the calculation location (metres);

v = aircraft groundspeed (nautical miles per hour or knots); and

L_{AE} = calculated or measured A-weighted sound exposure level at the calculation location (decibels).

As an example, assume that z = 90 m, y = 150 m, v = 500 knots, and L_{AE} = 115 dB. Equation (E.1) yields R = 79.1 dB/s. The applicable formula in Table 2 indicates that the corresponding level adjustment for this rapid onset rate is given by 11 lg(79.1/15) = 7.9 dB.

In U.S. customary units of feet for aircraft height and lateral offset, equation (E.1) becomes

$$\begin{aligned} R = 3.7 + \exp(&-1.1668 - 0.00185z \\ &-0.000581y + 0.0045v \\ &+0.02884L_{AE}) \end{aligned} \tag{E.2}$$

Annex F

(informative)

Estimated percentage of a population highly annoyed as a function of adjusted day-night sound level

F.1 Introduction

In 1978, T.J. Schultz published a relation between the percentage of a population expressing high annoyance to aircraft, road traffic and railway noise and the corresponding A-weighted day-night sound level. A few years later, Kryter (see Bibliography [6]) argued that the community response to transportation noise could not be represented by one single curve: for equal day-night levels, the percentage of respondents being highly annoyed by aircraft noise was higher, and the percentage of respondents being highly annoyed by railway sounds was lower than that for road traffic noise.

Revised curves published in 1994 by Finegold *et al.* were derived from a wider set of data than the set used by Schultz. The revised data show aircraft, road traffic and railway noise separately since, as noted earlier by Kryter, there was a systematic difference among them, at least at high sound pressure levels. Recently Miedema and Vos have concluded yet another meta-analysis and found somewhat similar systematic differences.

F.2 The Dose-response function

The dose-response relationship for road traffic noise obtained by Finegold *et al.* estimates the percentages of highly annoyed respondents that were slightly lower than the percentages from the Schultz curve. The dose-response relationship for road traffic noise obtained by Miedema and Vos, however, estimates percentages of highly annoyed respondents that are slightly higher than the percentages from the Schultz curve.

The average of the curves obtained by Finegold *et al.* and by Miedema and Vos virtually coincides with the Schultz curve. Therefore, for simplicity and historical significance, the Schultz curve is taken as the curve to define the percentage of a population that is highly annoyed (%HA) to road traffic noise as a function of the day-night sound level, L_{dn} determined for the free field condition (i.e., the reflection at the building is not taken into account). The solid line in Figure F.1 shows the Schultz curve. About 90% of the grouped results from the various field surveys would fall within the two broken lines.

The equation of the Schultz curve shown in Figure F.1 is given by

$$\%HA = 100 / [1 + \exp(10.4 - 0.132\, L_{dn})] \qquad (F.1)$$

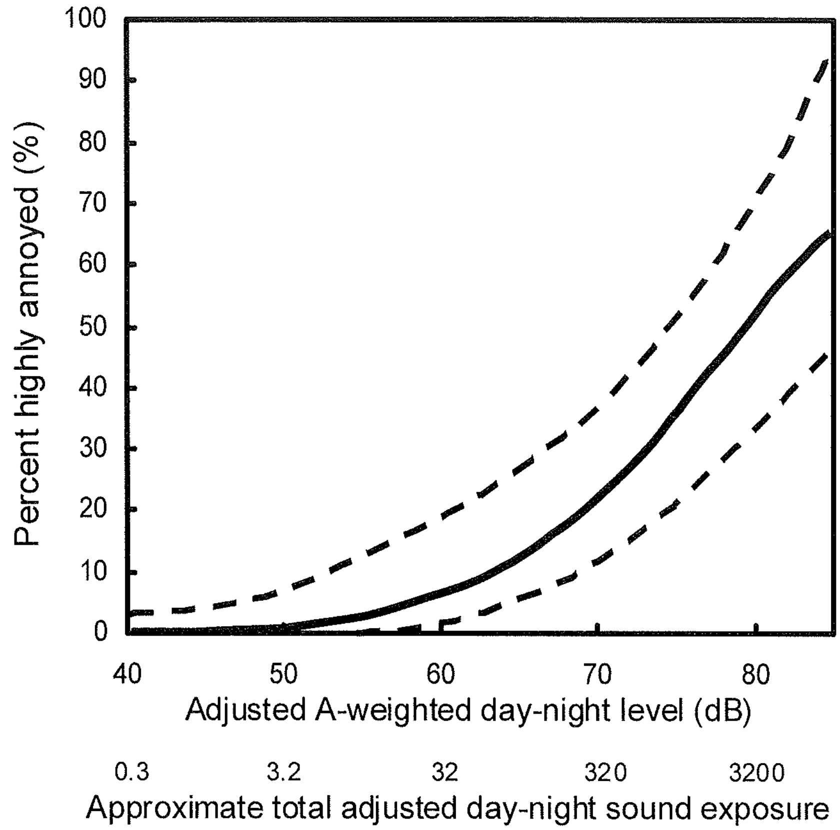

Figure F.1 — Percentage of respondents highly annoyed by road traffic sounds, as a function of the A-weighted day-night level

About 90% of the raw data points on which the average curve is based fall within the two dashed lines.

NOTE This dose-response relationship also can be used to assess the community annoyance response for other sources if the relevant source adjustments suggested in this document have been applied.

F.3 Qualifications to the dose-response function

F.3.1 Equation (F.1) is applicable only to long-term environmental sounds such as the yearly average.

F.3.2 Equation (F.1) should not be used with shorter time periods like weekends, a single season, or "busy days." Rather, the annual average or some other long-term period should be used.

F.3.3 Equation (F.1) is not applicable to a short-term environmental sound such as from an increase in road traffic due to a short-duration construction project.

F.3.4 Equation (F.1) is only applicable to existing situations.

F.3.4.1 In newly created situations, especially when the community is not familiar with the sound source in question, higher community annoyance can be expected. This difference may be equivalent to up to 5 dB.

F.3.4.2 Research has shown that there is a greater expectation for and value placed on "peace and quiet" in quiet rural settings. In quiet rural areas, this greater expectation for "peace and quiet" may be equivalent to up to 10 dB.

F.3.4.3 The above two factors are additive. A new, unfamiliar sound source sited in a quiet rural area can engender much greater annoyance levels than are normally estimated by relations like equation (F.1). This increase in annoyance may be equivalent to adding up to 15 dB to the measured or predicted levels.

For acoustical environments that include sounds with special characteristics, the annual-average adjusted day-night sound level L_{Ndn} should be used in equation (F.1) instead of the non-adjusted annual-average day-night sound level L_{dn}.

Table F.1 provides annual-average adjusted day-night sound levels at 1-dB increments and the corresponding total adjusted day-night sound exposures and percentages of highly annoyed.

Table F.1 — Annual-average adjusted A-weighted day-night sound levels and corresponding total adjusted day-night sound exposures and percentages of a population highly annoyed

Annual-average adjusted day-night sound level (dB)	Total adjusted day-night sound exposure (Pa^2s)	Approximate total adjusted day-night sound exposure (Pa^2s)	Percentage highly annoyed (%)	Annual-average adjusted day-night sound level (dB)	Total adjusted day-night sound exposure (Pa^2s)	Approximate total adjusted day-night sound exposure (Pa^2s)	Percentage highly annoyed (%)
40	0.3	0.3	0.6	61	43.3	40	8.7
41	0.4	0.4	0.7	62	54.5	50	9.8
42	0.5	0.5	0.8	63	68.6	63	11.1
43	0.7	0.6	0.9	64	86.4	80	12.4
44	0.9	0.8	1.0	65	109	100	13.9
45	1.1	1	1.1	66	137	125	15.6
46	1.4	1.3	1.3	67	172	160	17.4
47	1.7	1.6	1.5	68	217	200	19.4
48	2.2	2	1.7	69	273	250	21.6
49	2.7	2.5	1.9	70	344	315	23.9
50	3.4	3.2	2.2	71	433	400	26.3
51	4.3	4	2.5	72	545	500	29.0
52	5.5	5	2.8	73	686	630	31.8
53	6.9	6.3	3.2	74	864	800	34.7
54	8.6	8	3.7	75	1088	1000	37.8
55	10.9	10	4.1	76	1369	1250	40.9
56	13.7	12.5	4.7	77	1724	1600	44.1
57	17.2	16	5.3	78	2170	2000	47.4
58	21.7	20	6.0	79	2732	2500	50.7
59	27.3	25	6.8	80	3440	3150	54.0
60	34.4	32	7.7	81	4330	4000	57.2

NOTE 1 The relationships in Table F.1 also apply for annual-average day-night sound levels of environmental sounds without special characteristics or unusual community response.

NOTE 2 Table F.1 is applicable only to long-term environmental sounds such as the yearly average.

NOTE 3 Table F.1 is not applicable to "busy days" such as an average for say 30 days selected from a year because those 30 days had many noise-producing events and the other 335 days had many fewer such events.

NOTE 4 Table F.1 is not applicable to a short-term transient environmental sound such as from a short-duration construction project.

NOTE 5 Table F.1 is not applicable if there is sound-induced building vibration or rattles. Some studies have shown sound-induced building vibration or rattles to increase the equivalent annoyance by at least 10 dB. (See also D.7.)

Annex G

(informative)

Assessing the complaint potential of high-amplitude impulse noise

G.1 Introduction

Several decades of experience in handling noise complaints at military installations shows that substantive complaints typically result from the louder and/or more unusual events. Thus, a long-term average noise level metric arguably is not adequate alone to predict community complaint response, or indeed to protect against valid damage claims. A viable procedure is to supplement the long-term average (e.g. DNL) noise impact assessment procedure with risk criteria for community response in terms of complaints as a function of a single-event metric. Appropriate candidate metrics are suggested in Clause 4.1.1.

This annex provides a method to assess the complaint risk from military high-amplitude impulse sound such as the sounds produced by artillery or tank gun fire, bombs, military explosives, and similar civilian sources.[1] Historically, the peak level has been used with success to predict military blast noise complaints, though it does not account for the effect of event duration. Another candidate is the sound exposure level. For historical simplicity, the wide-band peak level is used in this annex. These risk criteria are only intended to be applied to blast noise events from large weapons such as artillery and tank guns and from fairly large explosions (approximately 0.1 to 100 kg). These sources exhibit considerable low frequency sound energy, with a sound exposure level spectrum that typically peaks in the range from 10 to 100 Hz. These noise complaint risk criteria should not be used for other sources of noise such as small arms noise and aircraft noise.

G.2 Complaint criteria

A set of risk criteria was developed by the Navy (Ref. 23) to guide decisions that balance risk of noise complaints against the cost or other consequences of canceling training or testing activity. These guidelines were based on records of complaints received, sound level measurements, sound level calculations, and balloon-suspended radiosonde meteorological soundings. The guidelines were also evaluated during a subsequent study (Ref. 26) and found to be a reliable method to predict complaints resulting from the firing of large guns. The risk criteria, presented in Table G.1, are expressed in terms of degree of complaint risk as a function of the value of the unweighted peak noise metric.

G.3 Complaint risk prediction

Large caliber weapons are very strong acoustic sources. The sound from firing these weapons can be easily audible at long distances, often as far as several tens of kilometers. Change in weather conditions can profoundly influence received noise levels. Sound propagation is influenced by vertical and horizontal profiles of values of atmospheric meteorological parameters such as temperature,

[1] For purposes of this annex, the weight of charge should be, approximately, between 0.1 and 50 kg.

humidity, wind speed and wind direction. Variation as large as 50 dB in received values of single-event noise metrics such as peak and SEL are routinely encountered (see for example Ref. 24).

The criteria presented in Table G.1 are based on the correlation of degree of risk of noise complaints for known event levels. Useful prediction of complaint risk also must take into account the expected statistical variation in received single-event peak noise level due to weather. If one predicts the mean peak level for all expected event levels, the actual noise level will be higher than the predicted mean level for 50% of all expected events, and may be higher by as much as 25 dB. This affords rather limited protection against receiving noise complaints, since a 25-dB change in event level can change complaint risk from low to high. On the other hand, basing risk of noise complaints on the maximum expected level would be far too conservative. An adequate procedure is to base assessment of complaint risk on a predicted exceedance level. As an example, consider PK15, the peak (unweighted) level that can be expected to be exceeded by 15% of expected blast noise events. A prediction of PK15 = 130 dB means that the risk of receiving a noise complaint would be expected to be high for 15% of all expected events. This strategy requires that the variance in received noise level due to weather effects are known, which is the case for blast noise from large guns.

Table G.1 – Complaint Risk Criteria

Risk of Noise Complaints	Large Caliber Weapons Noise Level (Unweighted Peak)
Low	< 115
Medium	115 – 130
High	130 – 140
Risk of physiological damage to unprotected human ears and structural damage claims	> 140

Annex H

(informative)

Loudness-level weighting

H.1 Introduction

The A-weighting filter can be replaced by the equal-loudness-level contours (Figure H.1) from ISO 226 (May 1987) as a dynamic filter that changes both with amplitude and with frequency. To approximate sound heard indoors, the sound is first filtered by a generalized house filter that is adjusted to approximate a window's slightly open condition—on the order of 5 cm (Figure H.2)[2]. This new method eliminates the need for the aircraft source adjustments in Table 2. Thus, with this new method, one can measure all transportation noise sources in a given situation. In effect, this new method provides a family of curves that vary systematically with sound frequency and level (Figure H.1).

Schomer (2000) shows that the use of loudness-level weighting provides for much better correlation with subjective annoyance responses than does the A-weighting. This new method uses fast-time-weighted one-third-octave-band spectra sampled every 100 ms over the duration of an event such as an aircraft flyby. Fast-time weighting is used to approximate the integration time of human hearing. Each spectral band level is replaced by its corresponding phon level using an analytical representation of Figure H.1. These phon levels are summed over time and frequency on an energy basis to form the loudness-level-weighted sound exposure level (LLSEL). The analytical representation is given in Table H.1.

H.2 The method

A sound event such as the sound of an airplane flyby or a truck passby is analyzed into one-third-octave bands. Human hearing is such that short-duration sounds are not perceived to be as loud as long-duration sounds. To be perceived with full loudness, sound must be present for a duration that is longer than the integration time of the ear. Thus, in this procedure, the one-third octave band spectra are *fast* time weighted and sampled every 100 ms. The *fast* time weighting is used to approximate the integration time of the ear which data indicate lies between 25 ms and 250 ms. Since the time constant for *fast*-time-weighting is 125 ms, 100 ms is an adequate rate with which to sample the spectra. This forms a time-series of one-third-octave-band spectra.

Equal-loudness-level contours are given in functional form in Table H.1 However, this method requires that the sound first be filtered by the house filter of Figure H.2 and as given in Table H.1. Then the analytical functions given in Table H.1 can be applied. The loudness-level functions and house filter in Table H.1 correspond to one-third-octave-band center frequencies from 20 Hz to 12,500 Hz. Each filtered one-third-octave-band sound pressure level (SPL) is assigned the phon level that corresponds to that frequency and level. For example, from Table H.1, a filtered one-third-octave-band SPL of 82 dB in the 125-Hz band would be assigned a value of 80 phon since it corresponds to a phon level of 80. Similarly, a filtered one-third-octave-band level of 82 dB in the 31.5-Hz band would be assigned a value of 51 phon.

---

[2] The house filter simulates the Sound Transmission Loss (TL) of a typical house, in this case with windows open about 2 cm, when sound is transmitted from outdoors to indoors.

The overall time-integrated phon level (LLSEL) is calculated from the time and frequency energy summation of the time-series of filtered one-third-octave band spectra. This time-series of 100 ms, filtered one-third-octave-band spectra is used to calculate the overall time- and frequency-summed phon level, L_L, that is given by:

$$L_L = 10\log\left\langle \sum_j \sum_i 10^{\left(L_{Lij}/10\right)} \right\rangle \tag{H.1}$$

where L_{Lij} is the phon level corresponding to the *i*th filtered one-third-octave band during the *j*th time sample.

The quantity calculated by equation (H.1), L_L, has been designated as the loudness-level-weighted sound exposure level (LLSEL). It is similar to the A-weighted sound exposure level (ASEL) except that instead of using a filter (A-weighting) that varies only with frequency, LLSEL uses a dynamic filter that varies with both SPL and frequency. Similarly, one can calculate loudness-level-weighted equivalent level (LL-LEQ) or loudness-level weighted day-night level (LL-DNL).

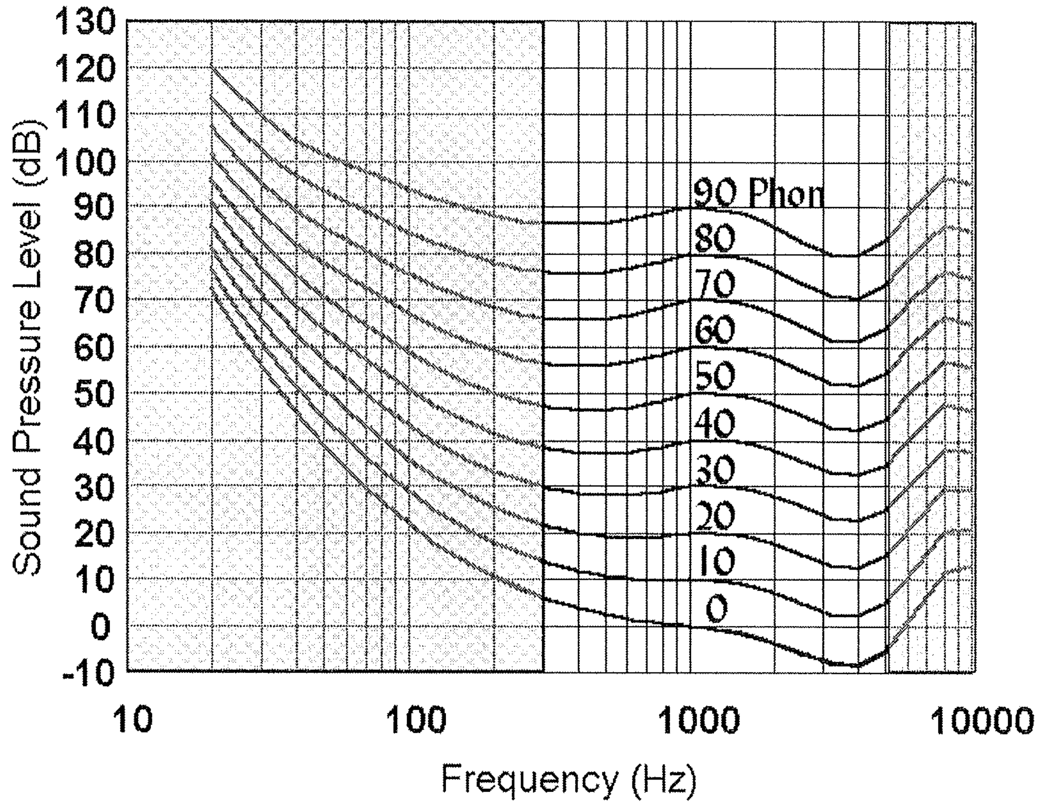

Figure H.1 — Equal loudness level contours in phons from ISO 226-1987. The non-shaded area shows the frequency range where, approximately, a 10-dB change in sound pressure level corresponds to a 10-dB change in phon level. At low frequencies this relationship does not occur. For example, at 31 Hz, a 10-dB change in sound pressure level corresponds to about a 20-dB change in phon level.

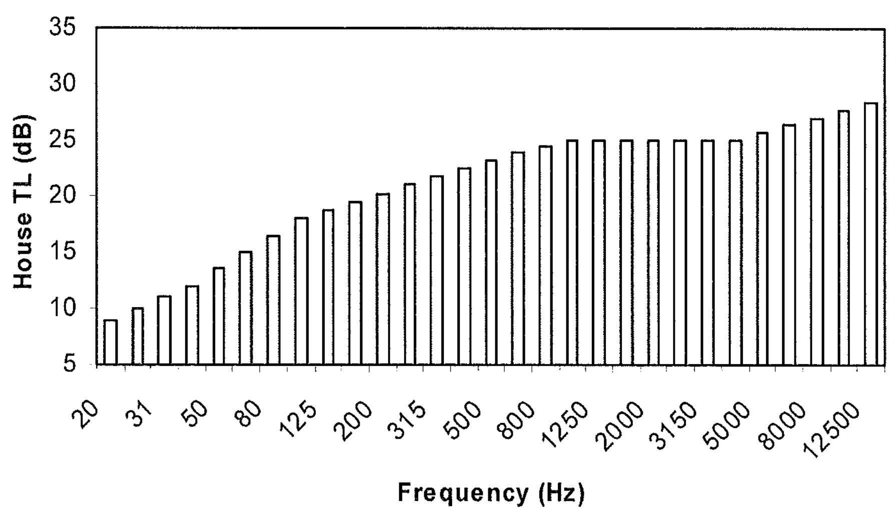

Figure H.2 — Generalized house TL for windows open on the order of 5 cm.

Frequency	20	25	31	40	50	63	80	100
af	2.347	2.190	2.050	1.879	1.724	1.597	1.512	1.466
Lu	0.00561	0.00527	0.00481	0.00404	0.00338	0.00286	0.00259	0.00257
Tf	74.3	65	56.3	48.4	41.7	35.5	29.8	25.1
House TL	9	10	11	12	13.5	15	16.5	18

Frequency	125	160	200	250	315	400	500	630
af	1.426	1.394	1.372	1.344	1.304	1.256	1.203	1.136
Lu	0.00256	0.00256	0.00254	0.00248	0.00229	0.00201	0.00162	0.00111
Tf	20.7	16.8	13.8	11.2	8.9	7.2	6	5
House TL	18.75	19.5	20.25	21	21.75	22.5	23.25	24

Frequency	800	1000	1250	1600	2000	2500	3150	4000
af	1.062	1.000	0.967	0.943	0.932	0.933	0.937	0.952
Lu	0.00052	0	-0.00039	-0.00067	-0.00092	-0.00105	-0.00104	-0.00088
Tf	4.4	4.2	3.7	2.6	1	-1.2	-3.6	-3.9
House TL	24.5	25	25	25	25	25	25	25

Frequency	5000	6300	8000	10000	12500
af	0.974	1.027	1.135	1.266	1.501
Lu	-0.00055	0	0.00089	0.00211	0.00489
Tf	-1.1	6.6	15.3	16.4	11.6
House TL	25.65	26.35	27	27.65	28.35

Table H.1 — Coefficients for calculation loudness level from band sound pressure level. The table also includes the house filter characteristics shown in Figure H.2.

For any band, loudness level is calculated from the respective band j sound pressure level, L_j by:

$$LL_j = 4.2 + [\mathrm{af}_i\,(L_i - \mathrm{Tf}_i)]/[1 + \mathrm{Lu}_i\,(L_i - \mathrm{Tf}_i)] \qquad \text{(H.2)}$$

where LL_j is the loudness level in the jth band.

The house TL is included by modifying (H.2) to:

$$LL_j = 4.2 + [\mathrm{af}_i\,(L_i - \mathrm{TL}_i - \mathrm{Tf}_i)]/[1 + \mathrm{Lu}_i\,(L_i - \mathrm{TL}_i - \mathrm{Tf}_i)] \qquad \text{(H.3)}$$

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NOTE The following references are available in the open literature or through the National Technical Information Service (NTIS). NTIS numbers are given at the end of each reference.

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