Approach to the Composing the Practicum on Safety Systems

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Abstract. The practicum creates conditions for the controlled formation of important competences. Generalized practical lessons for master's programs are promising. This paper proposes practicum concept in which the interest in abilities of certain safety means stimulates attention to the terms that cause difficulties. Questioning the master's degree students in «Technosphere safety» revealed sustained interest in effective means of acoustic safety as well as difficulties with the terminology of fire safety. Prepared generalized practical lesson on acoustic safety contains the following: fire danger indicators introduced into reference data; automated calculations of sound insulation; developed assessment procedure. Results of the generalized practical lesson in the control group have confirmed both overcoming difficulties with the terminology of fire safety and increasing the degree of readiness for the expertise of projects

1. Introduction
Practicums create conditions for the controlled formation of important students’ competences [1-4].

Assessment of competencies formed by means of discipline «Safety» for bachelor programs confirmed the wide opportunities of generalized practical lessons [5-7]. Obtained data indicated that generalized practical lessons are also justified for master programs. Questioning the master's degree students in «Technosphere safety» showed:
• Materials to ensure acoustic safety are stable interest.
• The terminology of fire safety is the difficulty.

The noted results allow assuming that difficulty could be overcome if during the practical lesson on the discipline «Calculation and design of safety systems» to take into consideration the fire hazard class of the considered materials, as well as fire hazard class and fire resistance limit of the projecting constructions. In addition, there would be conditions for forming the competence's component «readiness».

The purpose of the paper is improving the practicum on safety systems due to the generalized practical lesson.

The problems were solved:
• Complementing the acoustic safety reference data.
• Automating the calculations.
• Developing the assessment procedure.
• Realizing the generalized practical lesson in the control group.
2. Composing the generalized practical lesson

2.1. Complementing the acoustic safety reference data

Information about structures and materials [8-11] was introduced into acoustic safety reference data (tables 1, 2).

| Table 1. Options of walls with plates in a distance |
|--------------------------------------------------|
| **Wall** | **Plate on distance** | **Air layer** |
| material | fire hazard class | thickness (mm) | material | fire hazard class | thickness (mm) | thickness (mm) | mineral wool’s fire hazard class |
| Ceramsite concrete | K0 | 100 | Drywall | KM1 | 6.5 | 40 | KM0 |
| Foam concrete | K0 | 180 | PhoneStar | KM5 | 12.5 | 25 | KM0 |

| Table 2. Options of frame-sheath partitions |
|--------------------------------------------|
| **Type of partition** | **Structure** | **Fire resistance limit** | **Fire hazard class** |
| C111 | mineral wool plate: density 37 kg/m³, thickness 50 mm one layer of drywall: thickness 12.5 mm | EI 45 | K0 |
| C112 | mineral wool plate: density 37 kg/m³, thickness 50 mm one layer of fire-resistant drywall: thickness 12.5 mm | EI 60 | K0 |
| | mineral wool plate: density 37 kg/m³, thickness 50 mm two layers of drywall: thickness 12.5 mm | EI 60 | K0 |
| | mineral wool plate: density 37 kg/m³, thickness 50 mm two layers of fire-resistant drywall: thickness of 12.5 mm | EI 90 | K0 |

Fire hazard classes and fire resistance limits correspond with normalized [12, 13] values.
2.2. Automating the calculations
Calculations were automated by Excel spreadsheets. They give the following acoustic characteristics in the most acceptable form:

- Sound insulation of plate on distance (table 3).
- Sound insulation of single-layer wall (table 4).
- Sound insulation of single-layer wall with the plate on distance (table 5).
- Sound insulation of the multi-layer wall.
- Sound insulation index (tables 4, 5).

### Table 3. Option of calculating the sound insulation of plate on distance

| Parameter | Value                  | Values at geometric mean frequencies |
|-----------|------------------------|--------------------------------------|
|           |                        | 100 125 160 200 250 315 400 500 630 800 1000 1250 1600 2000 2500 3150 |
| t (m)     | 0.04                   |                                      |
| E (Pa)    | 19000                  |                                      |
| k (Pa/m)  | 4750000                |                                      |
| d (kg/m³) | 1100                   |                                      |
| h (m)     | 0.01                   |                                      |
| m (kg/m²) | 7.15                   |                                      |
| f₀ (Hz)   | 129.72                 |                                      |
| 3f₀ (Hz)  | 389.17                 |                                      |
| add₁ f>f₀| 0 0.43 0.18 0.07 0.03 0.01 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 | 0 0.43 0.18 0.07 0.03 0.01 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 |
| cₐ (m/s²) | 340                   |                                      |
| cₚ (m/s²) | 2500                  |                                      |
| f₀́̀ BOUN (Hz) | 3952.14     |                                      |
| l (m)     | 6.00                   |                                      |
| sₗ       | 0.01                   |                                      |
| n         | 6                      |                                      |
| add₂     | 0.06                   | 0 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 |
| add₃ f₀ 3f₀ | 0.06                   | 0 0.49 0.24 0.13 0.09 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 |
| add₂ f>3f₀| 0.06                   | 0 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 |
| Sound insulation R_ADD (dB) | 0 0 3.0 6.5 9.0 10.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5 |
Table 4. Option of calculating the sound insulation of the wall

| Parameter | Value | Values at geometric mean frequencies |
|-----------|-------|---------------------------------------|
| t (mm)    | 100   | 100 125 160 200 250 315 400 500 630 800 1000 1250 1600 2000 2500 3150 |
| f_B (Hz)  | 315   |                                       |
| d (kg/m³) | 1300  |                                       |
| m (kg/m²) | 130   |                                       |
| K         | 1.2   |                                       |
| m_EQ      | 156   |                                       |
| R_B (dB)  | 32    |                                       |
| R₁ (dB)   | 32    | 32 32 32 32 32 32 34 36 38 40 42 44 46 48 50 52 |
| Sound insulation index (dB) | 43 | 43 |

Table 5. Option of calculating the sound insulation of the wall with the plate on distance

| Parameter | Value | Values at geometric mean frequencies |
|-----------|-------|---------------------------------------|
| R₁ (dB)   | 32    | 32 32 32 32 32 32 32 34 36 38 40 42 44 46 48 50 52 |
| R_ADD (dB)| 0     | 0 0 3.0 6.5 9.0 10.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5 |
| R (dB)    | 32    | 32 32 35 38.5 41 42.5 46.5 48.5 50.5 52.5 54.5 56.5 58.5 60.5 6.5 64.5 |
| Estimative curve | 33 36 39 42 45 48 51 52 53 54 55 56 56 56 56 56 56 |
| Deviations down | 34.5 | 1 4 4 3.5 4 5.5 4.5 3.5 2.5 1.5 0.5 0 0 0 0 0 |
| Shifting the estimative curve | -1 32 35 38 41 44 47 50 51 52 53 54 55 55 55 55 55 55 |
| Deviations down | 23 | 0 3 3 2.5 3 4.5 2.5 2.5 1.5 0.5 0 0 0 0 0 0 |
| Sound insulation index (dB) | 51 | 51 |
Sound insulation index is determined to compare with the normalized [14-17] value.

2.3. Developing the assessment procedure

Fuzzy Logic Toolbox was used for assessment procedures (figure 1).

The system has two inputs, one output, three rules «if ... then», three values for the centers of the membership functions of the inputs and output.

Assessment of the manifestation of the indicator:

- 0 points if the indicator is absent.
- 5 points, if the manifestation of the indicator is unstable.
- 10 points if the indicator is stable.

Degree of «readiness» competence’s component formation:

- Low if there is no manifestation of any indicator.
- Average if the manifestation of the indicator of acoustic safety is unstable.
- High if fire safety indicator is stably manifested.

![Figure 1. Option of assessment procedure](image)

Self-assessment on acoustic and fire safety indicators is sufficient to fulfil a fuzzy expert system.

2.4. Realizing the generalized practical lesson in the control group

At the practical lesson control group master students worked on ensuring the acoustic comfort in the reconstructed room:

- The required index of sound insulation of walls and partitions was determined.
- The effectiveness of various sound insulation means was considered taking into account the permissible fire risk.
- Optimal design of the walls or partitions was calculated.
- Readiness to coordinate decisions and interact with other security experts was assessed in dynamics.
The following results have been obtained:

- Calculations and self-assessment automation ensure the sufficiency of study time.
- Interest in the characterization of new acoustic safety means stimulates attention to fire safety indicators.
- Proposed design solutions show increasing the readiness to coordinate design and interact with other safety professionals.

Thus, the suppositions of the appropriateness to clarify the practical lesson content on acoustic safety systems have been confirmed.

3. Conclusion

It is recommended to introduce into practicum on safety systems tasks that combine consideration of the fire hazard of materials and structures with the following calculations:

- Sound insulation of single-layer wall.
- Sound insulation of plate on distance.
- Sound insulation of single-layer wall with the plate on distance.
- Sound insulation of the multi-layer wall.
- Sound insulation index.

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