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1 Subject of specification

This specification used in conjunction with other technical specifications of LOTOS Group S.A., establishes minimal requirements regarding designing and implementation of factory-wide wired sound distribution system for administrative purposes.

2 Scope of validity

This specification shall be used when preparing both quotations and Purchase Orders concerning planned LOTOS Group S.A. new investments and modernizations.

It shall also be a base for preparation of other detailed specifications and quotations relevant for package units or other equipment deliveries.

2.1 Deviations

Any deviation from this specification and the relevant specifications, standards and related documents including proposals, which the bidder claims to be economically and / or technically superior solutions, must be submitted in writing for review and approval by Grupa LOTOS SA. Non-approved exceptions are not acceptable by Grupa Lotos S.A.

The supplier must report in writing any ambiguity in this or any other specifications of Grupa LOTOS SA or non-compliance with the referred documents / standards and obtain a written explanation from Grupa Lotos SA.

2.2 Exclusions

This specification does not include:

- Requirements for adaptation of acoustic structures of rooms
- Requirements for sound amplification systems for halls, conference rooms, audience halls, etc.
- Requirements regarding parameters of cables
- Requirements regarding routing and laying of cables.

3 Hierarchy of documents

In case of conflicts existing between this specification and other documents, the following order of precedence shall govern:

- The current Polish legislation
- Terms of purchase order / contract and other requirements agreed in writing with GLSA
- Data Sheets approved by GLSA
- This specification
- Other Specifications
- Drawings and other documents
- Standards

4 Definitions

4.1 Basic concepts

GLSA – Grupa Lotos S. A.

Sound pressure (p) – an increase of pressure in relation to average value of static pressure (atmospheric), produced by sound wave resulting in temporary concentration or rarefaction of air. Sound pressure produced by sound wave in air relates to variable component of atmospheric pressure,

and only this variable component acts on human ear. This range includes frequencies from 16 Hz to 20000 Hz, p= 1 μbar [1 dyn/1 cm^2]

Sound pressure level (SPL) – value determining acoustic state in specific point of acoustic field, and expressed in dB with formula: 20 lg p/p_0 where:

p – value of sound pressure in specific point of acoustic field, expressed in Pa

p_0 – reference sound pressure (2x 10^{-5}), expressed in Pa

Sound speed v_a, the speed of environment particles (e.g. air molecules), vibrating in effect of sound wave passing through the environment v_a= [m/sec]

Acoustic field, the space in which sound wave propagates.

Sound wave impedance Z_f, – sound pressure and sound speed ratio $Z_f= p/v_a$.

Sound intensity, that is sound power per unit of area perpendicular to wave propagation direction.

Sound intensity level, that is relative measure of sound intensity.

I= 10 log I/Io [dB]

where:

I – sound intensity level [dB]

I – sound intensity [W/m^2]

Io – reference sound intensity [W/m^2]

Sound loudness level, subjective comparison of given tone loudness to loudness level of 1000Hz frequency tone. The unit of loudness level is phon. Statements of loudness levels for speech and music are given by standardized isophonic contours.

Sound absorption A is determined by product of sound absorbing material area S and coefficient of sound absorption α, for that material.

A= S x α $[m^2]$

Reverberation time that is time, during which intensity of spatial sound, counting from moment of sound source action end, will diminish to 1 x 10^{-6} of its original value.
According to classical Sabine formula, reverberation time for room amounts to:

T= 0,161 x V / Ac [s]

where:

T - reverberation time, [s]

V - volume of room [m^3]

Ac - total sound absorption of room [m^2]

Speech Intelligibility Index - RASTI, that is conventional value resulting from simplified measurement of difference between sounds being "received" and sounds being "transmitted" (originals). RASTI measurement method (Rapid Speech Transmission Index) is simplified version of speech intelligibility measurement method STI (audio Speech Transmission Index). Method of RASTI index measurement is determined by IEC 268-16:1989 standard.
RASTI range relates to five groups of speech intelligibility: bad 0.1 – 0.3; poor 0.3 – 0.45; correct 0.45 – 0.6; good 0.6 – 0.75; excellent 0.75 – 1.0.

Rated output of amplifier, that is electrical power that can be permanently produced on rated load resistance, at rated output voltage and frequency 1 kHz.

Efficiency of loudspeaker, that is pressure level on the loudspeaker axis at 1 m distance, and electrical power of 1 W.

4.2 Ambient conditions

- Ambient temperature (max/min) — +36°C/-25°C
- Average monthly humidity (min/max) — 70%/90%
- Elevation above sea level — 1m
- Wind speed — 26 m/s
- Snowfall — 290 mm
- Atmosphere — typical for refinery Grupa Lotos S. A. (marine, aggressive industrial, chemical and dusty)

4.3 Electrical supply data

Electrical supply available on site:

Frequency	50 Hz
Low voltage:	230 VAC TN-S

5 Description

5.1 Basic assumptions

5.1.1 General data

Factory-wide wired sound distribution system for assurance of speech quality for transmission of verbal announcements and/or musical ones. Its basic functions include informing personnel during programs emitted on daily basis, and possibility for transmission of messages connected with personal safety.

Wired sound distribution system shall include in its range characteristic factory objects, in which employees are permanently present.

5.1.2 System architecture

Factory-wide wired sound distribution system for administrative purposes has distributed structure with 2-conductor loudspeaker lines (only phonic signal), consisting of:

- Main wire broadcasting centre
- Local wire broadcasting centre S-2
- Local wire broadcasting centre S-8
- Radiophonic cable transmission 100V network
- Connecting and protective strips located in radiophonic cable cabinets

Existing factory wire broadcasting centre is ranked among medium power wire broadcasting centres (below 2500 W), and if functional organization is concerned (broadcasting of messages and own programs) belongs to Cat. II.

Main wire broadcasting centre includes the following rooms: amplifiers room, director's room, studio and technical back-up facilities. Local wire broadcastings centres include amplifier rooms.

- Basic features of the system:
  - cooperation with various sources of phonic signals, as microphones, tape recorders, CD players, AM/FM tuners,
  - chime signal switch next to microphone, with possibility for disabling this function (option)
  - reception and transmission of radio programs, with possibility for disabling this function, reception and transmission of radio programs with possibility for announcing (messaging) by means of microphone
  - possibility for transmission of interviews carried out by telephone
  - possibility for live transmission of selected events
  - visual and aural monitoring of signals on outputs of tape recorder, CD-player, tuner, mixer of power amplifier, as well as on loudspeaker lines
  - possibility for frequency equalizing of broadcasted programs
  - full protection of wire broadcasting network against overmodulation
  - total immunity of power amplifiers to short-circuits and overloads on lines
  - reserve power amplifiers
  - recording possibility of broadcasted programs

Technical data:

- Basic features of amplifier:
  - rated output voltage 100V
  - output power 200W
  - symmetrical, transformer type input and output
  - full protection against overloads and short-circuits on line, and thermal overloads
  - regulation of modulation level
  - indicators of modulation and overmodulation levels
- Microphone inputs:
  - type of inputs symmetrical, transformer type
  - input impedance 1 kΩ
- Line inputs:
  - type of inputs asymmetrical, with summation of stereo signals
  - input impedance 47 kΩ
- Power outputs
  - type of lines symmetrical, transformer type, 100V
  - output power for individual lines 200 W

- Quality parameters:
  - frequency bandwidth 31,5 Hz up to 16 k Hz +0,5 dB/-1dB
  - non-linear distortions TPD 0,2 %
- Noises and interferences:
  - noises (A filter) - 90 dB
  - interferences (band-pass filter 22,4 Hz-22 k Hz) - 93 dB

Each radiophonic cable cabinet serves assigned objects located on terrain assigned to it by area criterion.

5.2 Design requirements

5.2.1 Basic components of the system

The following components can be distinguished for modification and/or extension purposes of wired sound distribution system:

- Stationary equipment
- Line equipment

5.2.2 Stationary equipment

- The amplifier

It is recommended to use power amplifiers of rated output 100 – 500W/100V.

Amplifiers of sound amplification system shall have power higher by approx. 10 dB than that required in order to obtain adequate level of sound pressure.

In sound distribution system reserve amplifiers are required, started automatically after failure of any operating amplifier.

- Electro-acoustic channel

Electro-acoustic channel of wired sound distribution system shall feature pass-band adequate for required quality of sound amplification:

Reproduction quality	speech	music
Very high	60 – 10.000 Hz	30 – 16.000 Hz
high	150 – 8.000 Hz	50 – 10.000 Hz
medium	300 – 6.000 Hz	120 – 8.000 Hz

High quality of sound amplification is recommended.

Narrower pass-bands are used only for transmission of messages on open area and in rooms of high interferences level.

Signal and noise ratio in electro-acoustic channel shall amount at least to 50 dB.

Recommended levels of sound pressure depending on type of reproduced program, shall amount to:

- for speech - 80-90 dB
- for light music - 90-95 dB

Useful signal level to noise level margin (sound amplification margin) shall amount at least to 25 dB for speech.

In relation to high interference level in room, sound amplification level margin can be assumed in order of 10 dB.

- Mixer console

Mixer console shall include the following characteristic modules:

- Microphone input modules
- Line input modules
- Stereophonic input modules with correction
- Totalling modules with limiter
- Audio monitoring modules
- Generator modules
- Auxiliary modules (remote control of tape recorders)

5.2.3 Line equipment

- Distribution frames for sound system

The following distribution frames for sound system can be distinguished:

1. object ones
2. storey ones

Design of distribution frame for sound system shall include enclosure of design adapted to environmental and constructional conditions of location, and equipment including at least:

- input modules
- overcurrent protection modules
- commutation modules
- output modules
- overvoltage protection modules (in justified cases it applies to object line distribution frames)

Cable terminals (screwed and/or quick-connecting) shall be adapted to planned diameters of cables and wires.

Overcurrent protection modules (fuse-links) shall be selected according to requirements of detailed project.

Object distribution frames for sound system are foreseen for termination of cables of radiophonic network led to object, and for further distribution of electro-acoustic channel over radiophonic and/or loudspeaker circuits.

Storey distribution frames for sound system are foreseen for further distribution of electro-acoustic channel over loudspeaker circuits on given storey of object.

Distribution frames for sound system can be located in MDF cabinets and made of elements enabling their assembly in 19” structures.

- Loudspeakers

Loudspeakers of sound amplification system shall be located in such a way, so that uniform sound amplification of entire room would be ensured. Non-uniformity of sound amplification measured in octave of mid-band frequency 4 kHz shall not exceed ±3 dB.

Basic knowledge of sound propagation principles and selection of proper loudspeakers (in terms of intended use and acoustic environment), along with their skilful arrangement, enables to obtain required parameters of speech intelligibility in sound amplification project. Another method consists in computer simulation of acoustics.

Analysis of environment noise, calculation of adequate sound intensity level and proper selection of loudspeakers' type (adequate for their destination), as well as their careful arrangement, are included in scope of so-called "acoustic design". Depending on size and nature of specific room, loudspeakers of 2 – 12W power can be used (wall loudspeakers), and bigger 20 – 40 W (horn loudspeakers).

- Division on loudspeaker circuits

Below listed factors shall be taken into account when making division on loudspeaker circuits:

- organizational structure of the works
- messages' transmission type
- functionality of equipment
- power of loudspeaker equipment
- allowable voltage drop

Selection of proper loudspeaker.

When selecting loudspeaker within frames of acoustic design, one shall take into account:

1. Sound pressure level (SPL)

2. Speech intelligibility

When electrical power of loudspeaker is doubled, then sound pressure level (SPL) is increased by 3 dB.

Sound pressure level decreases by 6 dB when distance from specific loudspeaker is doubled.

Sound distribution system shall be designed in such a way, so that sound pressure level produced by loudspeaker would exceed normal environment noise level in most quiet moments by at least 10 dB.

Types of loudspeakers

1. Omnidirectional loudspeaker

2. Bi-directional loudspeaker

3. Directional loudspeaker

Loudspeakers destined for typical applications shall be equipped with matching transformer with tapping, enabling possibility of electrical power adjustment/selection.

The loudspeaker shall be provided with built-in sound intensity regulator. In justified cases (high-standard buildings or rooms), wall regulators or remote regulators are used.

The system shall ensure proper speech intelligibility (at least 0.5 RASTI) in each place of public access.

Sound amplification system shall ensure good intelligibility of verbal announcements. Intelligibility drop for consonants shall not exceed 15%.

Below listed factors, influencing speech intelligibility, shall be taken into consideration:

1. environment noise
2. loudspeaker coverage angle
3. room cubature
4. finishing of walls
5. distance from loudspeaker
6. loudspeaker's sound transmission curve
7. reverberation
8. echo.

Ad. 1 Environment noise results in masking effect, and at 96 dBA level – safe hearing of messages is in practice impossible (use of loudspeaker system conforming to OSHA standard is impossible)

Ad. 2 Loudspeaker coverage angle, that is an angle within range of which the loudspeaker radiates sound energy of frequency in range 0.8 – 4 kHz. As a rule, coverage angle is contained in the area, crossing of which brings about sound pressure level (SPL) drop by 6 dB.

Ad. 3 As a rule, the bigger room cubature, the poorer speech intelligibility.

Ad. 4 Finishing of walls (surfaces of high sound absorption can bring about loss of required sound intensity level, while smooth and hard surfaces bring about creation of reverberation and echo).

Ad. 5 Distance from loudspeaker – the closer to loudspeaker, the better speech intelligibility.

Ad. 7 Reverberation causes blurring of intelligibility. The longer reverberation time, the poorer speech intelligibility. This is the case of rooms of improper acoustic dampening).

Ad. 8 Echo – the longer echo, the less intelligibility.

- Volume level regulators

Volume level regulators are used for individual and/or group regulation of loudspeakers volume, and are required when specific loudspeaker(s) does not have own built-in regulator, or when is (are) installed on height (wall, ceiling) making direct user access impossible.

Considering construction and use, one can distinguish:

1. resistance type regulators

2. electronic regulators (of transformer type)

Resistance regulators are used mainly for regulation of individual loudspeakers, or group of loudspeakers of total power not exceeding 12 W.

Electronic regulators (of transformer type) are mainly used for regulation of loudspeakers' groups of total power not exceeding 70 W.

- Sound system cable cabinets

  According to standard 3730, sound system cabinets constitute component of cable networks.

- Cable and wiring network

  Wiring network can be divided on:

  1. controlling network
  2. 100V transmitting network, made of separate cables

  Analyses of transmission networks shall be executed in the following way:

  1. In case of transmission lines of length 1.5 – 2.0 km, one shall use formula for voltage drop applied for calculations of direct current networks. For this type calculation voltage drop in network shall not exceed 10% of rated voltage.
  2. In case of transmission lines of length above 2.0 km, one shall use calculations taking unit parameters of channel into account (as for long distance line)

- Interior systems

It is recommended to lead sound system installation wires in separate guards (e.g. installation conduits) over or under plaster work, according to requirements of BN-84/8984-10 standard.

Distribution frames for sound system can be embedded in MDF cabinets and/or made of elements enabling their assembly in 19" structures.

Location arrangement of sound system loudspeakers in typical office rooms shall be planned on walls, on height of 1.8 – 2.2 m.

The loudspeaker shall be connected to electro-acoustic channel by means of installation branching connectors and/or connecting outlets.

Volume regulators, individual and/or for group of loudspeakers, shall be installed on walls on 1.5m height in easy visible and accessible places.

Maintenance of the installation and system shall be executed periodically, according to manufacturer's directions.

5.3 Electric supply

GLSA shall provide the Supplier with supply circuits, separated for feeding of wired sound distribution equipment, according to required power demand specified by the Supplier.

The Supplier shall ensure overvoltage protection of equipment. Such protection shall guarantee safety of sound system equipment, as well as other components of the system in case of impulse electromagnetic discharge.

5.4 Marking

Factory-wide wired sound distribution equipment shall be marked with name and logo of manufacturer, in order to ensure complete system integrity. Each device shall be equipped with label showing dedicated number of equipment according to documentation and numbering procedure of linked devices. The label shall be printed by means of stamping on data plate. Data plates shall be made of stainless steel, non-corroding alloy or rigid plastic, and durably fastened to non-removable part or equipment frame. The Supplier shall submit proposal of label for GLSA approval prior to starting of production.

5.5 Services

The services that the Supplier shall provide are as follows:

- implementation design
- system programming
- factory acceptance test and inspection
- packaging and shipment
- assembly on site
- functional tests and connections to other systems
- training of GLSA personnel
- maintenance during guarantee period

5.6 Cables, wires, auxiliary items

All cables, wires, prongs, accessories and mechanical protective equipment shall be included in scope of Supplier delivery. Cabling of wired sound distribution system shall include all required connections to equipment provided by the Supplier. All cables and terminal strips shall be marked on each end, following marking system according to GLSA standard N° 6120.

All equipment destined for outdoor installation shall be delivered together with cable glands. The Supplier shall make selection of cable glands according to nominal diameters of cables, specified by their producer.

5.7 Documentation

Documentation shall include the following components:

1. Technical description, including:
   - description of existing equipment
   - description of newly designed equipment
   - description of operating principles
   - calculations of electrical parameters of the system
   - detailed description of system elements
   - list of relevant norms and other documents.
2. Equipment lists
3. Cable lists
4. Drawings:
   - description of graphical symbols
   - block diagrams
   - building layouts showing equipment and cable arrangement on different floors
   - field layouts (geodetic maps) showing equipment and signal/power cable arrangement for outdoor areas (e.g. process plants)
   - station and line equipment arrangement drawings

- wiring diagrams (cabling)
- supply diagrams
- drawings of console arrangement
- assembly examples

5. Operating, installation and maintenance instructions
6. As-built documentation, including revised drawings, reflecting changes introduced to equipment and wiring system.
7. Start-up checklist
8. Acceptance report

Prior to detailed designing commencement, the Supplier shall agree requirements for system (i.e. system functionality, location of equipment, cable routing) with GLSA representatives. Such adjustments shall be prepared in written form.

6 Relevant documents

Any "Technical Specification" issued by GRUPA LOTOS S.A. listed in Contract Files.

7 Norms and standards

It is in each case understood that quoted standards, regulations, directives and orders are of their latest editions, along with amendments, annexes and supplements in force.

7.1 Regulations

THE LAW of 30 August 2002, on conformity assessment system (Journal of Laws 02.166.1360)

Minister of Economy order of 21 August 2007, on basic requirements for electrical equipment (Journal of Laws 2007.155.1089 as amended)

The Law of 13 April 2007 on electromagnetic compatibility (JoL 2007.82.556).

7.2 Norms

- PN-T-04499-01 Sound system equipment. General provisions.
- PN-T-04499-02 Sound system equipment. Basic terms and methods of calculations.
- PN-EN 60268-3 Sound system equipment. Part 3: Amplifiers.
- PN-EN 60268-4 Sound system equipment. Part 4: Microphones.
- PN-EN 60268-5 Sound system equipment. Part 5: Loudspeakers.

8 Enclosures

- Attachment No 1, Block diagram: Main wire broadcasting centre
- Attachment No 2, Block diagram: Local wire broadcasting centre

9 Record of changes

No.	Date	Description	Introduced by
1	30-11-2013 (rev. 1)	Review, update, standardize and changes to the Standard within scope of order No. OK/990/2012	Editorial board coordinated by T.Wróbel
-	31-08-2015	Page layout corrections, no contents changes.	T. Wróbel