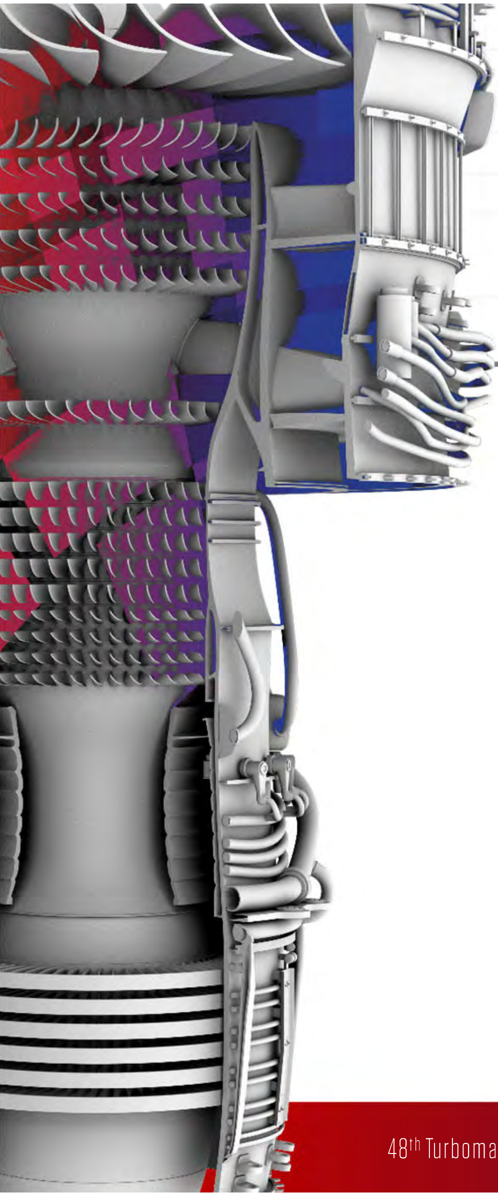

TURBOMACHINERY & PUMP SYMPOSIA

Gas Turbine Noise Abatement Case Study

Upgrading an initial designed noise control system to reduce excessive noise levels

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Biographical information

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Outline

- Description of Turbo Compressor train
- Problem Statement
- Seven-step Noise problem-solving algorithm
- Identification and segregation of dominant sound sources
- Selection and validation of noise solutions
- Implementation
- Site verification of noise mitigation measures
- Lessons learned and recommendation

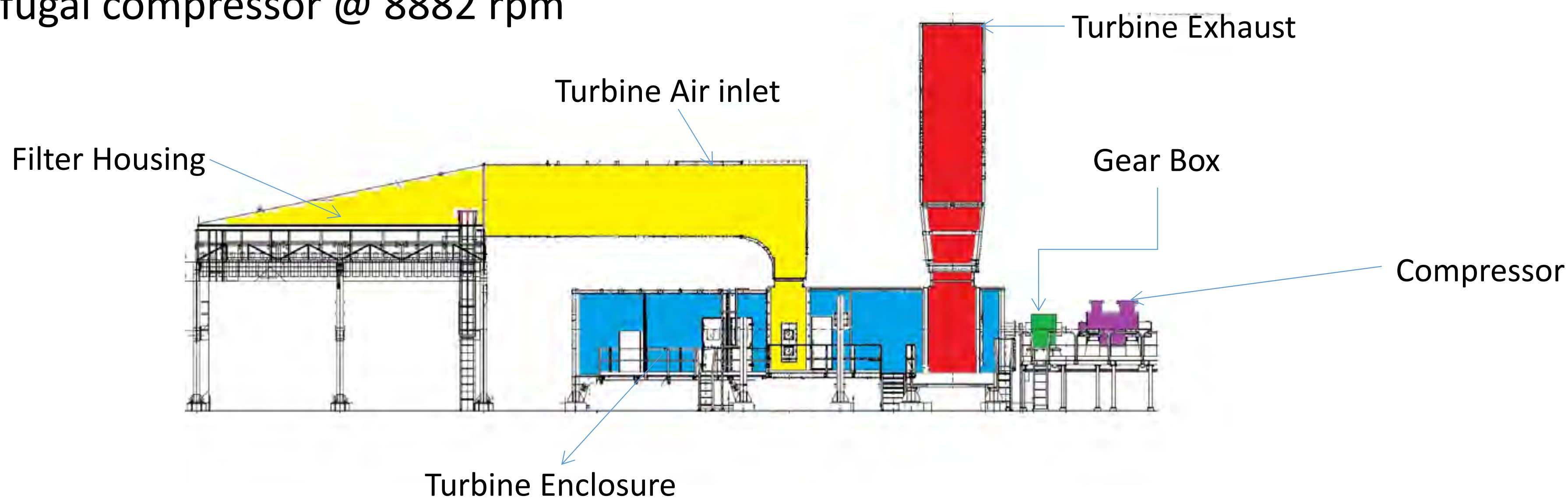
Problem Statement

- Gas turbines are frequently used as one of the main drivers for machinery. In this case study, the Gas turbines drive centrifugal compressors.
- The gas turbine driver was designed with standard noise enclosure and insulators. Nevertheless, the noise levels surrounding the turbine exceeded the accepted occupant noise levels (85 dB A at accessible areas)
- Detailed analysis is required to reduce the noise taking into consideration:
  - Minimum cost Noise abatement solution.
  - Minimum compression station downtime due to new Noise lagging material insulation.

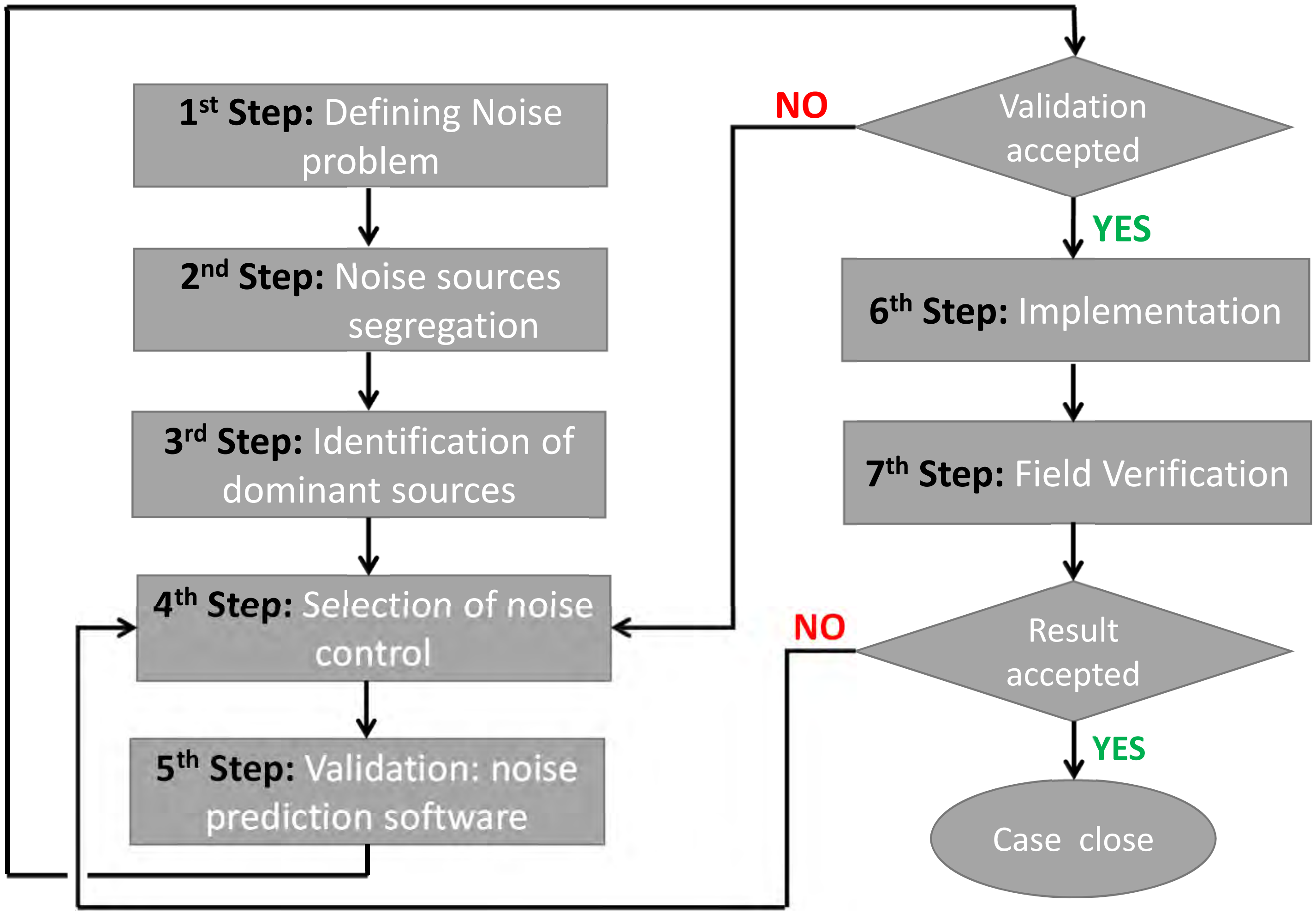
Turbo Compressor Details

<u>Turbo compressor consists of the following:</u>

1. Gas turbine 28340 kw (ISO rating) @ 4670 rpm
2. Gear box (gear ratio of 1.90)
3. Centrifugal compressor @ 8882 rpm

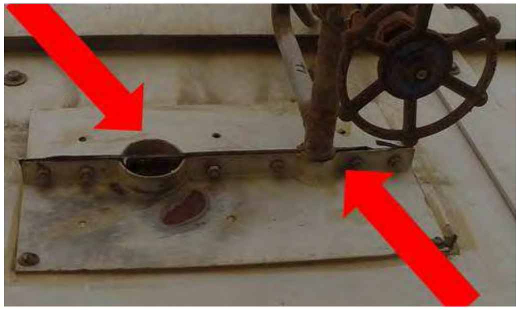


Seven-Step Noise Problem-Solving Algorithm



Defining Noise Problem

Site survey to examine the current status of the enclosures and analyze the possible causes of excessive noise emission.



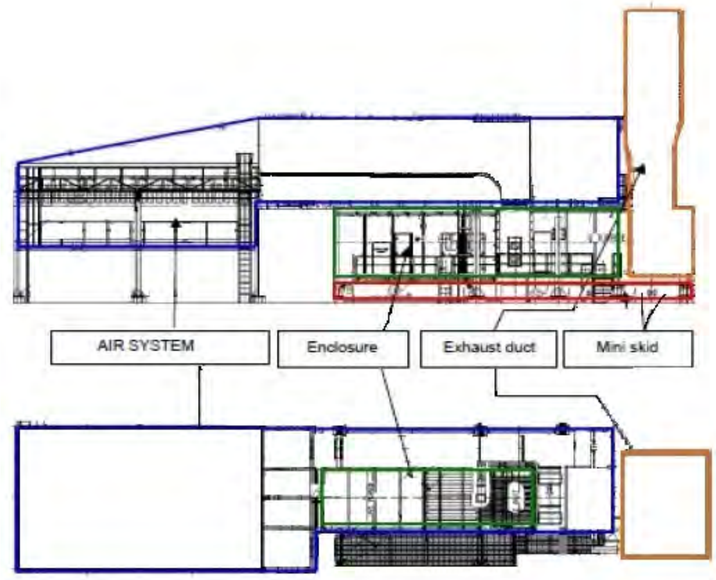
The following was found:

1. The condition of the enclosure is good (except for pipe sealing).
2. Pipe's sealing: All the pipe sealings were not correctly installed. All the internal parts of the sealing and the insulation material between the sealing were not installed
3. At GT enclosure (around access platform) the sound pressure levels exceed the required limit of 85 dB A @ 1 m. The maximum sound pressure level is 92.5 dB A close to the GT inlet plenum.

Noise Sources Segregation

- Gas turbine noise sources principally come from the air intake (including air filters), air compression section, the combustor, power turbine and the exhaust stack

- The intensimetric technique performed according to ISO 9614, allows the determination of the noise sources' sound power levels by eliminating the reflection and external noise sources' contributions.

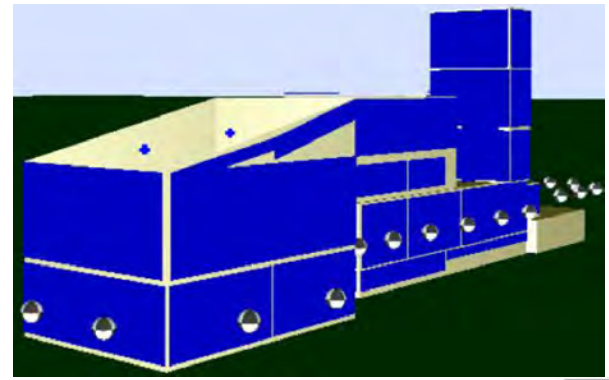


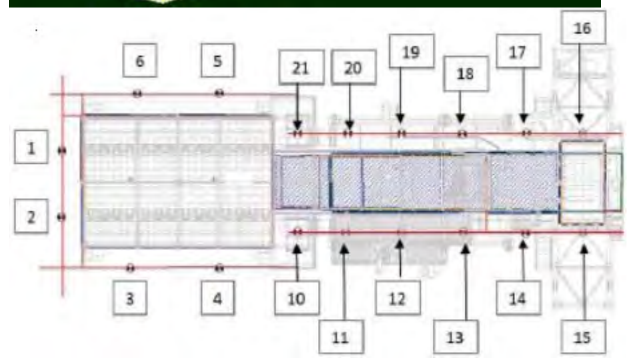
- In order to calculate the sound pressure levels around the turbine a numerical noise prediction software was used to perform a complete a noise model utilizing the sound power levels measured at site.

Noise Sources Segregation

Noise prediction software evaluate the acoustic propagation outdoor following standard calculation defined as guide lines referring various methods in ISO 9613.

Sound pressure levels obtained by simulation are calculated at the shown different receiver locations and listed in the following table:





@ Turbine Filter House

Receivers location	1	2	3	4	5	6
Current noise emissions (dB A)	82.9	82.7	82.4	84	84.2	83.6

Receivers location	10	11	12	13	14	15	16	17	18	19	20	21
Current noise emissions (dB A)	89.6	88.6	88.5	92.5	88.9	88	88.6	89.2	91	88.3	88.8	89

@ Gas Turbine Enclosure

Identification of Dominant Sound Sources

The main contribution on sound pressure levels around the turbine enclosure are (in a descending order):

1. Close to the turbine **air inlet** plenum
2. Close to the turbine **Exhaust** panel
3. Around the turbine **baseplate**

The GT enclosure suffered improper sealing between the piping and enclosure, that may have reduced the originally designed noise attenuation however this was not the main cause of high noise levels

Selection of Noise Control

1. Applying Acoustic panels (barrier) on **air inlet plenum** vertical walls with the following typical composition:
    - External 3 mm steel sheet
    - Mineral wool density 80 Kg/m3 & thickness of 80 mm
    - Internal perforated 1 mm steel sheet

2. Applying acoustic panels (barrier) on **exhaust plenum** vertical walls with composition same as air inlet plenum vertical walls

3. Applying **baseplate** miniskirts (short barrier) with the following typical composition:
    - External 10 mm minimum thickness steel sheet
    - Mineral wool density 80 Kg/m3 & thickness of 80 mm
    - Internal 1 mm perforated steel sheet

Validation

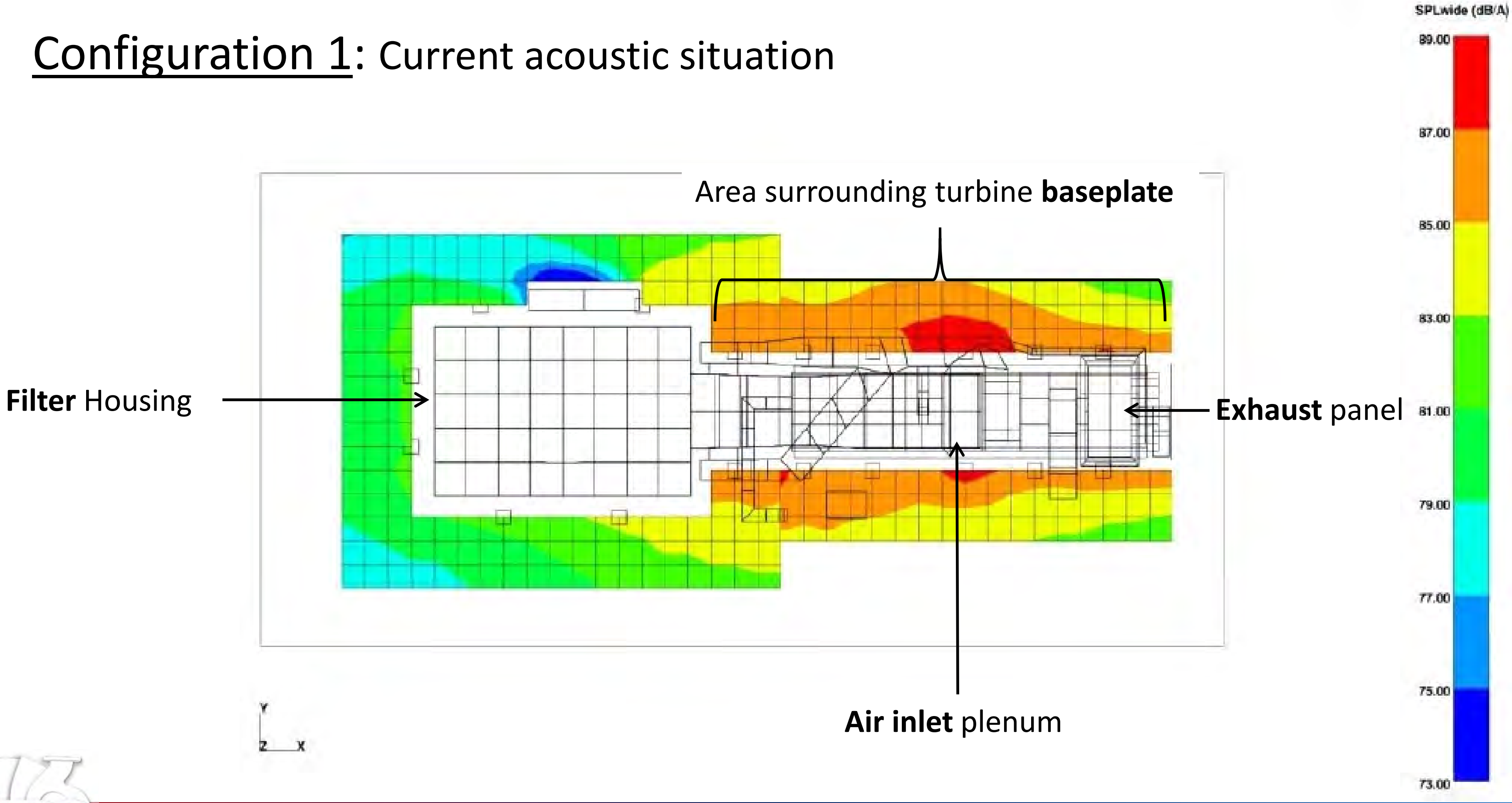
The aim was to simulate the effectiveness of acoustic mitigations selected as described in the following Configurations:

- Configuration 1: Current acoustic situation
- Configuration 2: Configuration 1 + inlet plenum vertical walls noise reduction
- Configuration 3: Configuration 2 + exhaust plenum vertical walls noise reduction
- Configuration 4: Configuration 3 + gas turbine enclosure cross piping seal repairs and gasket replacement
- Configuration 5: Configuration 4 + gas turbine baseplate miniskirts

The above configurations were consecutive steps until reaching the final configuration 5.

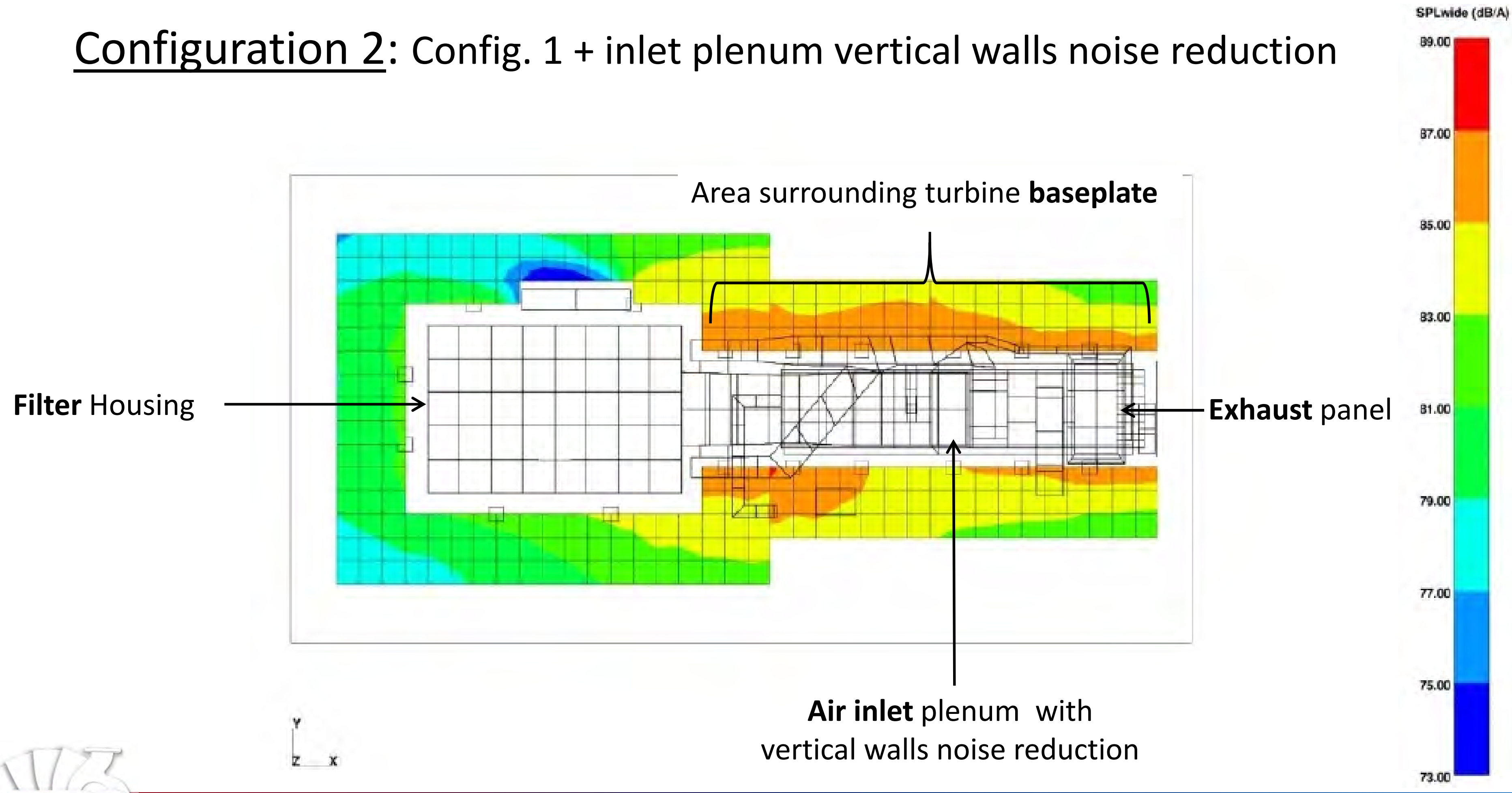
Validation

<u>Configuration 1</u>: Current acoustic situation



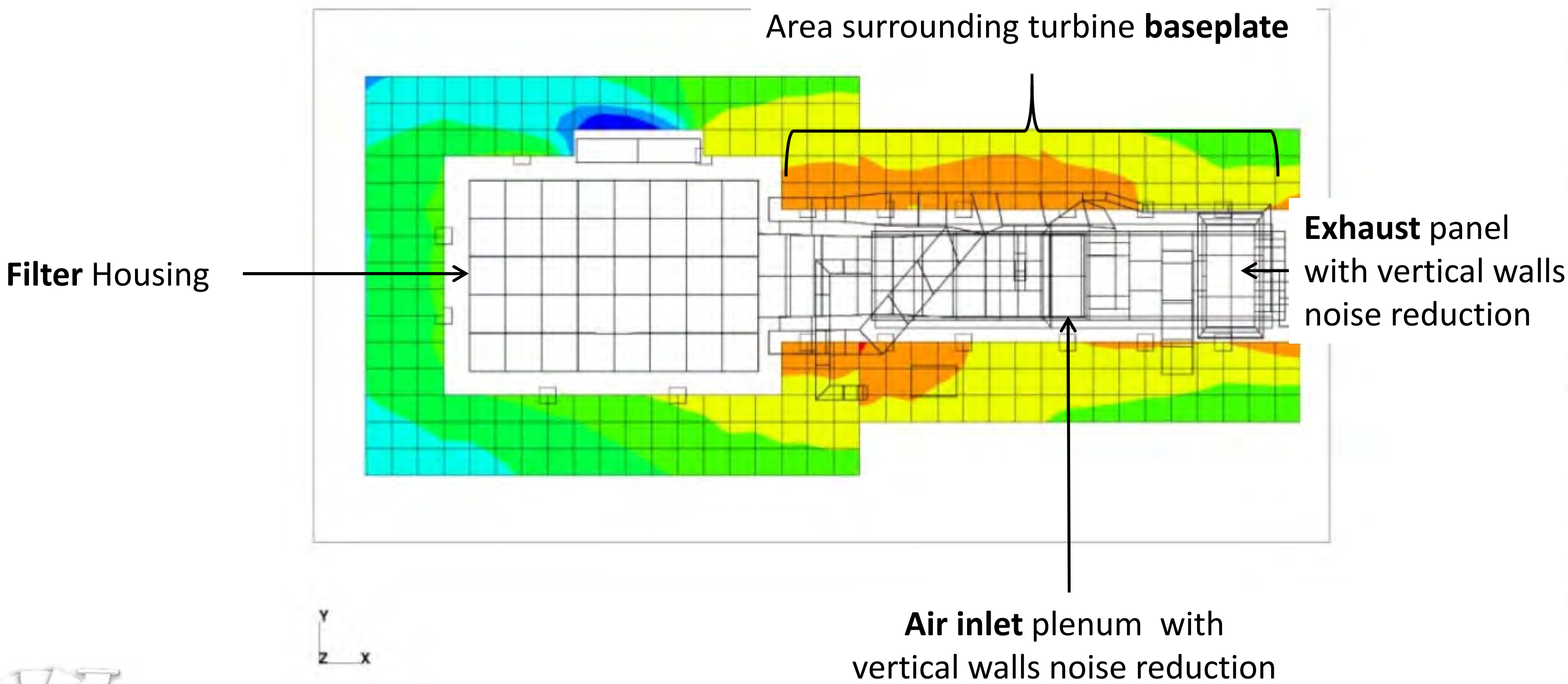
Validation

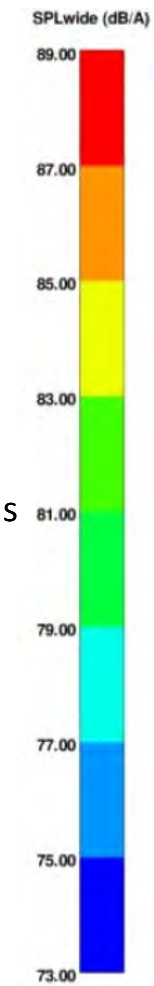
<u>Configuration 2</u>: Config. 1 + inlet plenum vertical walls noise reduction



Validation

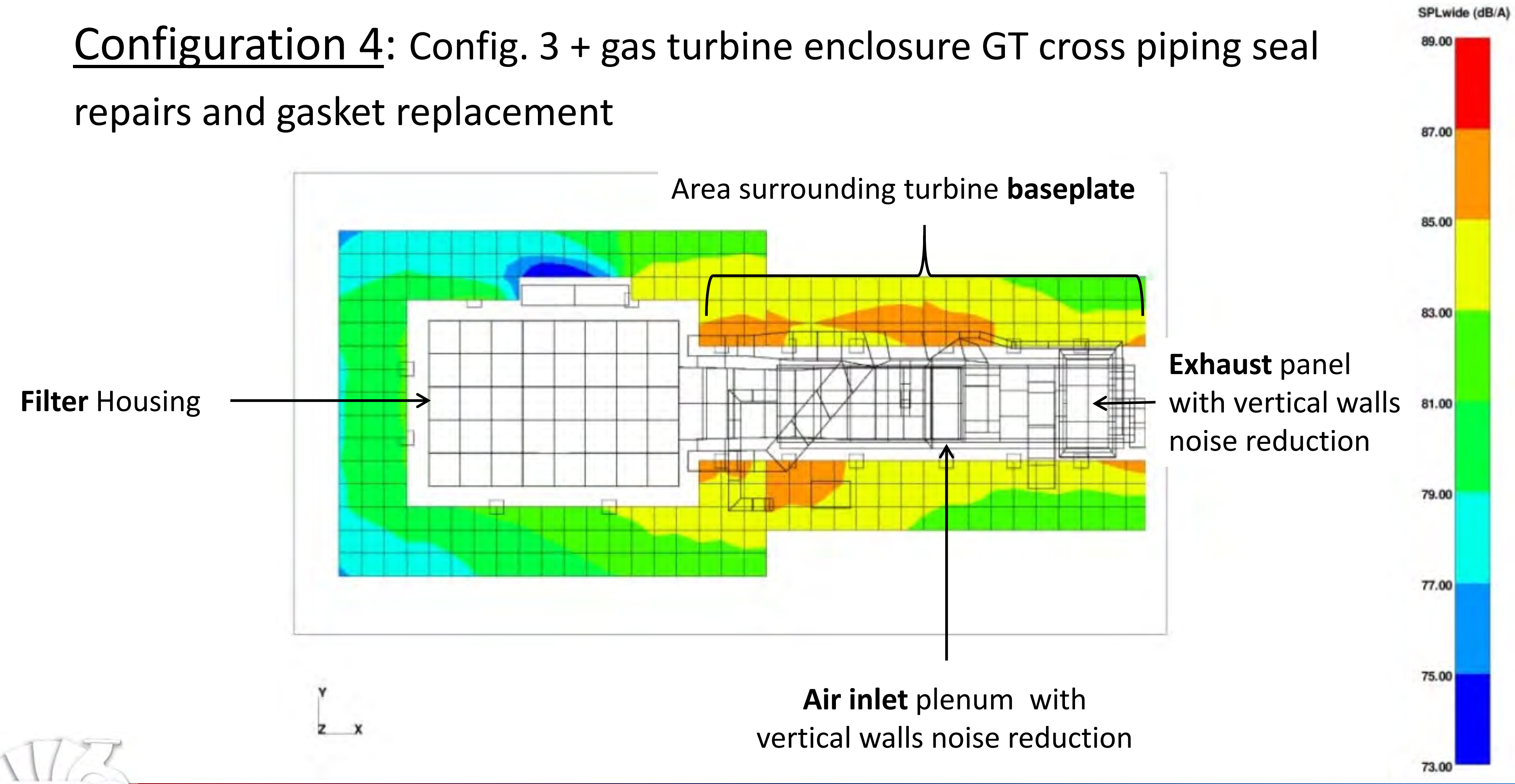
<u>Configuration 3</u>: Config. 2 + exhaust plenum vertical walls noise reduction





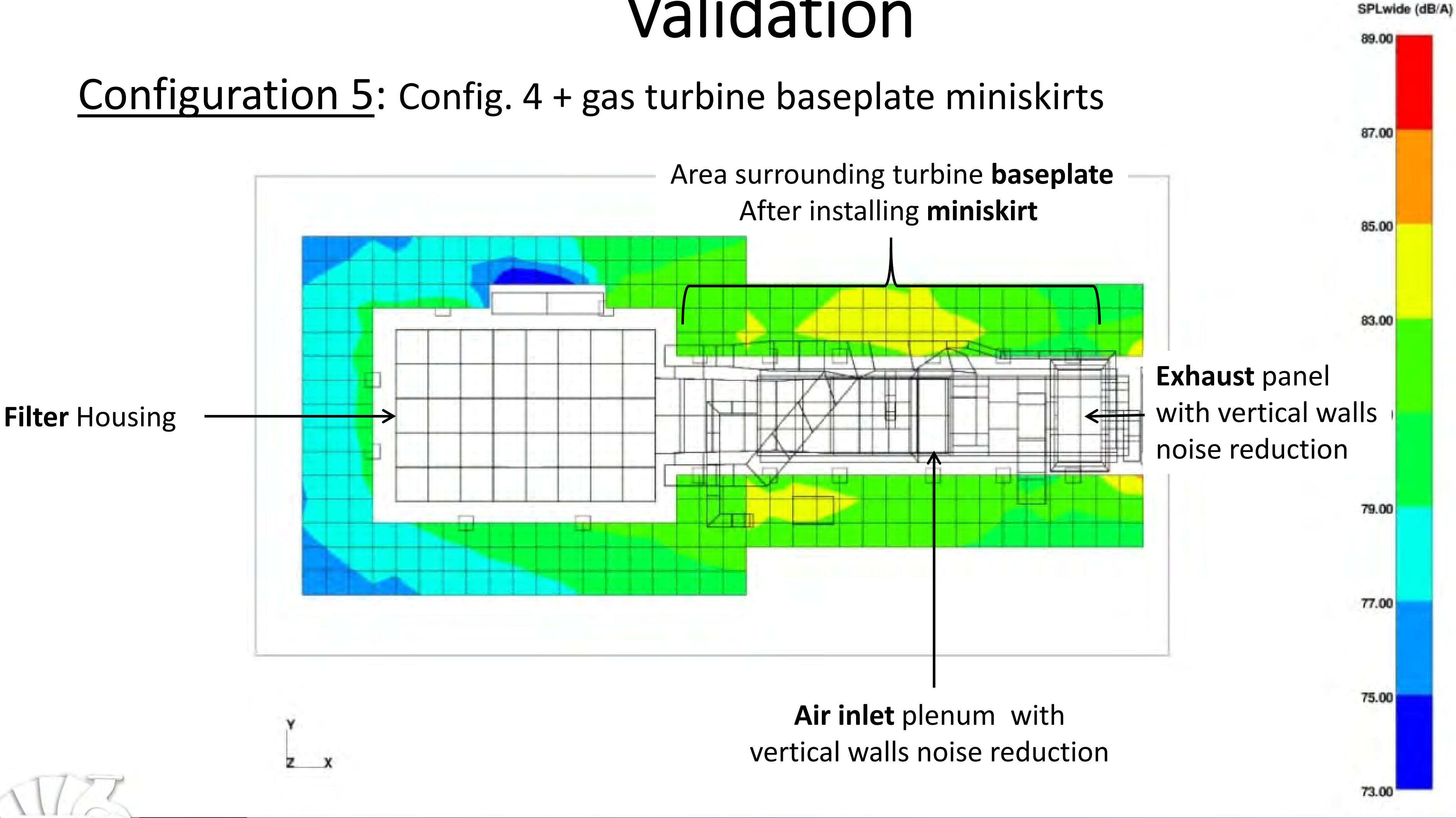
Validation

<u>Configuration 4</u>: Config. 3 + gas turbine enclosure GT cross piping seal repairs and gasket replacement



Validation

<u>Configuration 5</u>: Config. 4 + gas turbine baseplate miniskirts



Implementation

Before applying Inlet vertical wall reduction

After applying Inlet vertical wall reduction
Inlet vertical wall on the back and front side

Implementation

Before applying Exhaust vertical wall reduction

After applying Exhaust vertical wall reduction

Implementation

Gas turbine enclosure cross piping seal repairs and gasket replacement

Implementation

Before applying baseplate miniskirt

After applying baseplate miniskirt

From back and front side of baseplate

Site Verification of the applied Noise Mitigation Results

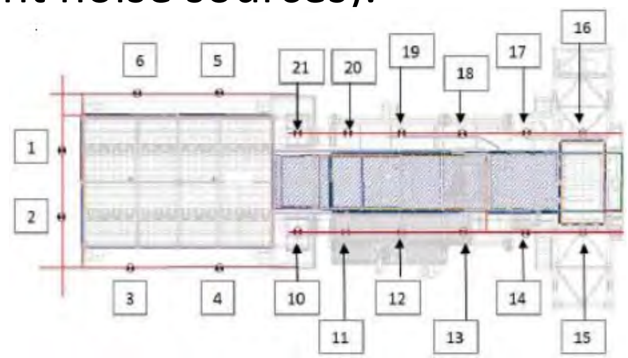
- Following the noise mitigation implementation the sound intensity test was repeated on turbo-compressor 3rd train with the pulse jet system of all the trains was turned off during the test.
- The following table shows the sound power levels (octave band in dB) and the global value in dB and dB (A) after the noise mitigation installation.

Location	63	125	250	500	1000	2000	4000	8000	Sum	Sum (A)
Exhaust	110.2	104.4	99.7	95.8	92.2	95.7	97.6	90.5	112	102.7
GT Enclosure	106.4	86.9	89.5	85.3	77.4	87.8	88.5	82	106.7	93.5
Base Plate	104.1	84.6	96.0	90	84.2	86.2	84.2	81.6	105.1	93.7
Inlet Air + Filter House	111.8	107	100	98.9	97.4	95.3	108.1	100.3	114.8	110.3

Site Verification of the applied Noise Mitigation Results

The following table shows the simulation before and after the acoustic mitigations installation.

The pressure levels are presented in the same positions around the turbine (that have been selected earlier during analyzing and segregating different noise sources).



@ Turbine Filter House

Receivers location	1	2	3	4	5	6
Before new noise mitigation (dB A)	82.9	82.7	82.4	84	84.2	83.6
After new noise mitigation (dB A)	79	78	78.8	80.6	81	79.6

Receivers location	10	11	12	13	14	15	16	17	18	19	20	21
Before new noise mitigation (dB A)	89.6	88.6	88.5	92.5	88.9	88	88.6	89.2	91	88.3	88.8	89
After new noise mitigation (dB A)	81.4	81.6	81.8	83.2	81.8	82.2	82.4	82.9	84.7	82.7	82.3	82

@ Gas Turbine Enclosure

Lessons Learned and Recommendation

- **Seven-step Noise problem-solving algorithm** is sequential and depends on the nature of the problem. Although it is an iterative process where the solution is subject to uncertainties and develops as it progresses, it still can be adopted to wide range of noise control problems.
- **Differentiation** between the contribution of each noise source to the overall noise emission is essential to have a successful solution with fewer iterative cycles
- **Areas surrounding turbines and compressor** are usually noisy and exceed 85 dB A. Even a standard noise enclosures and noise lagging component might not be sufficient to reduce max. noise levels by 85 dB A.
- **High Noise levels** is a complex and persistent problem as it has direct effect on human health, where the effects may not be observable immediately, yet the effects could have repercussions over time.

Questions