CARS Report on

Reduction of the sound level during the locking and unlocking operations of small-calibre guns

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PI

Dr. Paragmoni Kalita

Co-PI

Dr. Seikh Mustafa Kamal

Department of Mechanical Engineering

Tezpur University

Tezpur- 784028, Assam, India

Funded by

Defence Research Laboratory, Tezpur

Coordinating Scientists

Mr. Utsab Deb, Scientist 'D', DRL, Tezpur

Dr. Ananta Saikia, Scientist 'F', DRL, Tezpur

Abstract

Small-calibre guns, widely used in military operations for their agility and rapid response, include a safety mechanism to prevent accidental discharge. However, this mechanism produces audible clicks during locking and unlocking operations, potentially compromising soldier positions during secret operations such as ambushes. This study investigates methods to reduce the sound generated by the safety locking mechanism of the INSAS Mark 1 gun without altering its original materials and compromising its functionality. Two approaches were explored: (i) application of surface coatings to the ratchet wheel and plunger to reduce metal-on-metal impact sounds, and (ii) modification of spring stiffness through controlled heat treatment to soften the plunger's engagement. Experimental trials using a Class I precise dB meter revealed that grey-coated ratchet wheel-plunger pair showed promising sound reduction with sufficient coating thickness and chemical composition, not revealed by the coating service provider. Spring heat treatment resulted in up to 27.23% reduction in sound levels, and the combination of heat-treated springs with sufficient surface coatings yielded even greater attenuation, up to near-background noise levels under test conditions. This study demonstrates the feasibility of engineering sound-reduction modifications to enhance the strategic utility of small-calibre guns during secret operations, while maintaining safety and mechanical integrity.

Declaration by the Investigators

We hereby declare that the project titled "Reduction of the Sound Level During the Locking and Unlocking Operations of Small-Calibre Guns" has been carried out by us in accordance with the objectives and scope defined in the project proposal. All work presented in this report is original and has been conducted with integrity. The data collected, experimental procedures followed, and the results obtained are true to the best of our knowledge and have not been submitted or published elsewhere.

24.07.2025

(Dr. Paragmoni Kalita)

PI

24.07.2025

(Dr. Seikh Mustafa Kamal)

Co-PI

Department of Mechanical Engineering,

Tezpur University,

Tezpur, 784028, Asam, India

Mech. Engg. Dept. - Tezpur University - date 24.07.2025

1 Introduction

Small-calibre guns are extensively used in modern military operations due to their compactness, ease of handling, and rapid-fire capabilities. One of the critical safety features incorporated into these weapons is a locking mechanism designed to prevent unintentional discharge due to accidental pressure on the trigger. This mechanism ensures operational safety under normal conditions and is crucial for preventing mishandling-related incidents. However, this safety feature poses a strategic limitation in specialized scenarios, such as ambushes or secret mission, where silent operation is crucial. The distinctly audible sound generated during the locking and unlocking operations can reveal a soldier's position to nearby enemies. Even small mechanical sounds can put the mission and soldiers at risk. Recognizing this operational challenge, the current study focuses on exploring methods to reduce the sound level produced during the locking and unlocking of small-calibre guns without compromising the mechanical integrity or safety of the weapon. The aim is to modify or innovate the existing locking mechanism so that it remains functionally reliable and perceptible to the user, while keeping the sound low enough to avoid alerting the enemy. By addressing this balance between safety and secrecy, this study aims to enhance the strategic effectiveness of small arms in sensitive military operations.

2. Problem Statement

The need for noise reduction in the locking and unlocking mechanism of small-calibre guns was raised by end users involved in ambush operations. While the users expressed concern regarding the audible sound level during the locking-unlocking operations, no specific data or performance benchmarks were provided regarding the existing sound level or desired reduction. To address this gap, an initial investigation was conducted using the INSAS MARK 1 gun, a standard gun in operational use by the Indian Army. Experimental observations revealed that the average sound generated during the locking and unlocking operations was in the range 68–76 decibels (dB), measured using a Class 1 dB meter. In quiet environments such as during ambush missions, this level of sound may be sufficient to be detected by nearby enemies or even noise-sensitive animals, potentially indicating the soldier's position.

The aim of this study is to develop a solution that reduces the locking-unlocking sound to a level perceptible to the user but not to surrounding entities that could alert enemies. Since no target dB level was specified by the user, the goal is to reduce the sound to a level low enough to merge with the natural background noise found in outdoor environments such as forests or hills. The solution must ensure that the weapon's mechanical integrity and safety are not compromised. Additionally, no changes to the original materials are permitted.

3 Objective of the Project

The objective of the project is to innovate the current locking mechanism of a small-calibre gun by reducing the sound (dB level) created during the locking-unlocking operations of the safety mechanism.

4 Proposed Methodology

Three different routes were proposed initially without doing any major changes in the existing locking mechanism as follows:

a) Surface Engineering Process:

Applying surface coating on the ratchet wheel and the plunger (locking lever) with compatible sound-absorbing materials: Different types of sound-absorbing coating materials, e.g., ceramic coatings etc. can absorb the sounds generated due to metal-to-metal impact [1–4]. The composition of the coating and the thickness determine the compatibility with the base metal and its effectiveness. Extensive experiments will be carried out by varying the coating material and thickness to arrive at the best combination without compromising its functionality and performance.

b) Stiffness Optimization of Spring:

Optimizing the stiffness of the spring used for engagement and disengagement of the locking mechanism: The spring force plays an important role in the sound level generated. Theoretical and experimental analysis will be carried out for optimizing the spring stiffness, which is affected by the wire diameter, coil diameter, number of turns and modulus of rigidity.

c) Tolerance Analysis:

To optimize the tolerance for resistive release of the lock to reduce the metal-to-metal impact velocity and sound level.

The proposed methodology is divided into the following activities:

i. Selection of a suitable coating material for attenuation of sound produced by metal-to-metal impact velocity.

ii. Application of identified coating materials with varying thickness on the test specimen suitable as per tolerance.

iii. Experimentation on measurement of sound level (dB) produced by the locking-unlocking assembly during locking and unlocking with coated components.

iv. Adhesion test and wear test on the coated surface to check the bond strength of the coating and its wear life.

v. Optimization of the coating material and thickness through above experimentations and tests.

vi. Design and development of the spring with optimized stiffness.

vii. Tolerance optimization of the related mechanism for resistive release of the locking mechanism to reduce metal-to-metal impact velocity and sound level.

5 Analysis of Existing Locking Mechanisms

The locking and unlocking mechanism of the INSAS MARK 1 gun consists primarily of a ratchet wheel, plunger, and a compression spring. These components work together to engage or disengage the safety mechanism.

5.1 Working Principle and Sound Generation

The working principle of the locking and unlocking mechanism responsible for generating audible sounds was visually inspected and is described below.

Locking Operation

Rotation of the Ratchet Wheel: When the user initiates the locking motion by turning a safety lever, the ratchet wheel rotates to a specific position. This wheel has slots that provide discrete locking step.

Plunger Engagement: A spring-loaded plunger is positioned to rest against the slot of the ratchet wheel. As the wheel rotates, the plunger is compressed and then moved into a specific slot or groove, where it is held there firmly by the spring. This action creates a sharp clicking sound due to metal-on-metal contact.

Spring Force: The tiny spring behind the plunger stores energy during compression and releases it quickly when the plunger drops into the ratchet slot. This sudden release contributes significantly to the audible click during locking.

Unlocking Operation

Reverse Rotation: During unlocking, the ratchet wheel rotates in the opposite direction, repeating the same cycle of plunger compression and release, generating a similar click.

5.2 Primary Sources of Sound and Targeted Solution

The primary sources of sound are identified as

- Metal-on-metal contact between the plunger and the ratchet slots, and
- Sudden spring action that drives the plunger into position

The dominant clicking sound occurs due to the interaction between the plunger and the ratchet wheel, driven by spring force, and is present during both locking and unlocking operations. Although these sounds provide useful feedback to the user, they may alert the enemies to ruin the ambush mission. Therefore, targeted sound reduction efforts were focused on modifying the contact surfaces or adjusting the spring characteristics, without altering the original materials, in accordance with project constraints.

6 Design Modifications and Innovations

To achieve the objective of reducing the locking and unlocking sound in the INSAS Mark 1 gun, three technical approaches were initially proposed as discussed in Section 4:

1. Application of specialized surface coatings to reduce metal-on-metal impact noise
2. Modification of spring stiffness to reduce the intensity of the plunger's movement
3. Tolerance analysis of mating components to minimize play and vibration

Requests were made by the PI through the funding agency to ARDE, Pune, the original designer of the weapon, for providing the component drawings with specified tolerance values. However, no formal response was received from ARDE. As a result, it was decided to drop the third route, i.e., tolerance analysis, and proceed with the first two approaches.

To perform experiments related to the first two approaches, 20 sets of components (each set comprising a ratchet wheel, plunger, and spring) were obtained from the Indian Army through proper channels. The methodologies followed in the coating application and spring modification are described as follows.

6.1 Surface Coating Approach

The surface coating was proposed to be carried out through an external research service provider, due to the unavailability of coating facilities at Tezpur University and the limited project funding. However, external support for the coating process was initially difficult to secure. After several setbacks, assistance was eventually obtained from Mr. Sandeep Soley of Dazzle Dyna Coat, Maharashtra, through a contact facilitated by ARDE, DRDO. A limited number of components were successfully coated and tested for sound attenuation using an INSAS MARK 1 gun, with the support of the 68 Engr. Regt. of the Indian Army stationed at Solmara, Tezpur. However, the coating thickness and composition were not disclosed by the service provider. Consequently, only qualitative observations on sound reduction were possible, and precise material characterization could not be performed.

Initial sound tests were conducted using a mobile app-based dB meter. Later, a precise digital dB meter was procured within the project budget, and all subsequent measurements were conducted using this calibrated device, ensuring greater accuracy.

6.2 Spring Modification Approach

The second approach focused on reducing the spring stiffness through heat treatment at various temperatures, ranging from 200 °C to 600 °C. Before and after the heat treatment cycles, the stiffness of each spring was measured to evaluate the degree of reduction. Following this, a series of controlled tests were carried out using the INSAS MARK 1 gun to assess the impact of reduced spring stiffness on sound generation during locking and unlocking. This method resulted in a measurable reduction in sound and contributed to the overall solution. The heat treatment was performed using a muffle furnace in the Department of Mechanical Engineering at Tezpur University.

7 Experimental Details

The experimental study was carried out in three successive stages to assess the impact of surface coatings and spring stiffness modifications on the sound level during the locking and unlocking operations of the INSAS MARK 1-gun safety mechanism. Each stage of the experiment was designed to independently assess the impact of individual modifications, followed by an evaluation of their combined effect on the overall sound levels during the locking-unlocking operation of the mechanism.

7.1 Stages of Experiments

To achieve the objective of sound attenuation during the locking and unlocking operations of the safety mechanism of INSAS MARK 1 gun, the experimental work was structured into the following three stages:

7.1.1 Stage 1: Application of Surface Coating and Sound Measurement

In the first stage of the study, the contact interfaces between the ratchet wheel and the plunger were coated by Mr. Sandeep Soley of Dazle Dyna Coat, Sangli, Maharashtra. To facilitate this, a limited number of ratchet–plunger pairs from the actual gun safety mechanism as received from Indian Army were provided to the supplier. The coatings were selected by the supplier based on our requirement for sound absorption and the availability of materials at their facility. Initially, the supplier was also unsure which coating would be most effective in attenuating sound. As a result, five coatings were applied on a trial-and-error basis. These coatings were visually identified by their colours: green, black, matt black, grey, and white. However, no information regarding the chemical composition or thickness of the coatings was disclosed by the supplier. The coated samples were then assembled into the locking mechanism of the INSAS MARK 1 gun. To evaluate the effectiveness of each coating, sound level measurements were performed during the locking and unlocking operations. A mobile app-based sound level meter (dB meter) was initially used for this assessment. Measurements were taken at fixed distances ranging from 0 to 3 meters from the source, simulating practical field conditions. Multiple readings were recorded for each coated configuration at each distance, and the results were averaged. Baseline measurements using uncoated, as-received components were also taken under identical test conditions for comparison.

Based on the initial results, the two coatings that demonstrated the most significant reduction in sound levels were selected for further investigation. To study the influence of coating thickness, additional ratchet–plunger pairs were sent to the supplier for surface treatment. However, the coated samples were returned without any accompanying information regarding the coating thickness or chemical composition. Instead, the supplier labelled the coated sets with markings such as Sample 1, Sample 2, Sample 3 etc., presumably corresponding to varying, but undisclosed, coating thicknesses. Given the lack of quantitative data, the effect of the coloured coatings on sound attenuation could only be qualitatively assessed. A few additional rounds of coated samples were later provided by the supplier, again without any technical details about the coatings. These samples were tested to further evaluate the role of surface coating in reducing sound levels. For all subsequent tests in this stage, a calibrated precision sound level meter, procured specifically under this project, was used to ensure greater accuracy and reliability in the measurements.

7.1.2 Stage 2: Spring Stiffness Characterization and Heat Treatment

In the second stage, the focus was on evaluating the role of spring stiffness in influencing the sound attenuation performance of the mechanism. The original, as-received spring used in the locking system was tested to determine its initial stiffness using a Spring Stiffness Testing Machine procured under this project. Following this, a heat treatment process was conducted using a muffle furnace available in the department of Mechanical Engineering, Tezpur University. The springs were subjected to incremental heat treatment at temperatures ranging from 200 °C to 600 °C. Post heat treatment, the stiffness of each spring was re-evaluated using the same testing apparatus to examine the changes induced by thermal treatment. Subsequently, both treated and untreated springs were integrated into the gun mechanism paired with uncoated ratchet-plunger surfaces to perform sound level measurements under the same test procedure as described in Section 7.1.1. This allowed a direct comparison of the reduction in sound levels resulting from variations in spring stiffness alone.

7.1.3 Stage 3: Combined Effects of Coating and Spring Stiffness

In the third and final stage, the combined influence of surface coatings and heat-treated springs was assessed. The best coated samples with a specific colour code were paired with the treated springs that showed the most significant change in stiffness. The composite assemblies were again mounted onto the gun mechanism, and sound level measurements were performed as per the same procedure. The results from these measurements were compared with four key baseline configurations:

- Uncoated sample + Untreated Spring (fully unmodified case)
- Uncoated sample + Heat-treated Spring (effect of heat treatment only)
- Coated sample + Untreated Spring (effect of coating only)
- Coated sample + Heat-Treated Spring (Combined effect of coating and heat treatment)

This comparative analysis provided a comprehensive qualitative understanding of how each modification, independently and in combination, affects the sound attenuation performance of the locking mechanism.

7.2 Equipment Details

To perform the stages of experiments discussed in Section 7.1, the following equipment were used for the different measurements and the heat treatment of springs:

- Sound level meter
  Make: Casella
  Specifications: Class 1 sound level meter with range 10 dB to 143.3 dB in a single range + Class 1 acoustic calibrator + Analysis software + Tripod
- Spring stiffness testing machine
  Make: Systems & Controls
  Specifications:
  Load Range: 0-2 Kg
  Resolution: 0.01 gms
  Accuracy: +/- 0.5% of FSD
  Supply: 230 V, 50 Hz, 1 Phase.
- Muffle Furnace
  Make: Reico
  Specifications:
  Maximum operating Temperature: 950°C
  Accuracy: ±1°C
  Power Supply: 3kW
  Heating Elements: Kanthal Wire
  Heating Chamber: Heat treated refractory muffle body with insulation by bricks shall
  Temperature controller: Digital Temperature controller cum Indicator

  The photographs of all the equipment used in the present study are shown in Figs. 1–3.

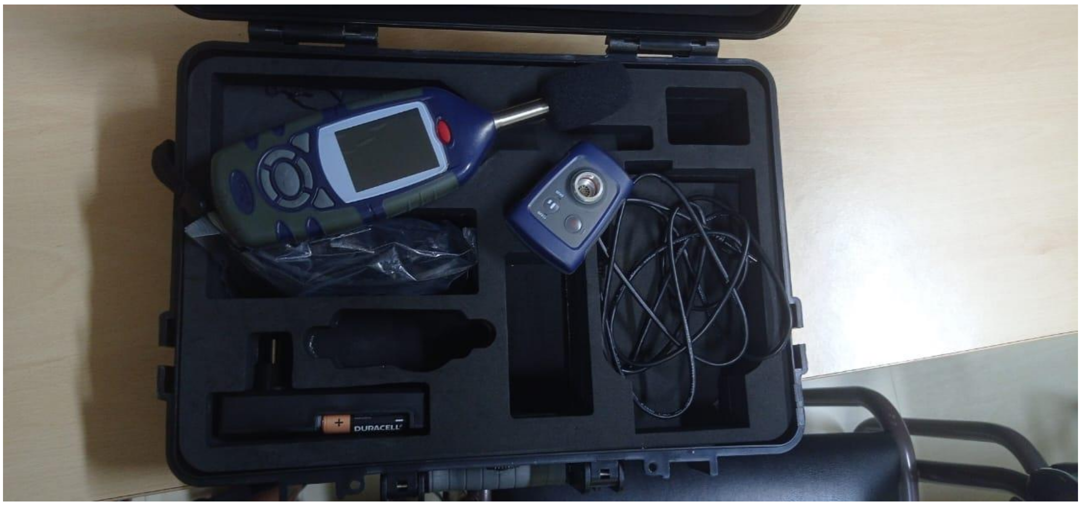

Fig. 1 The Class 1 Sound Level Meter

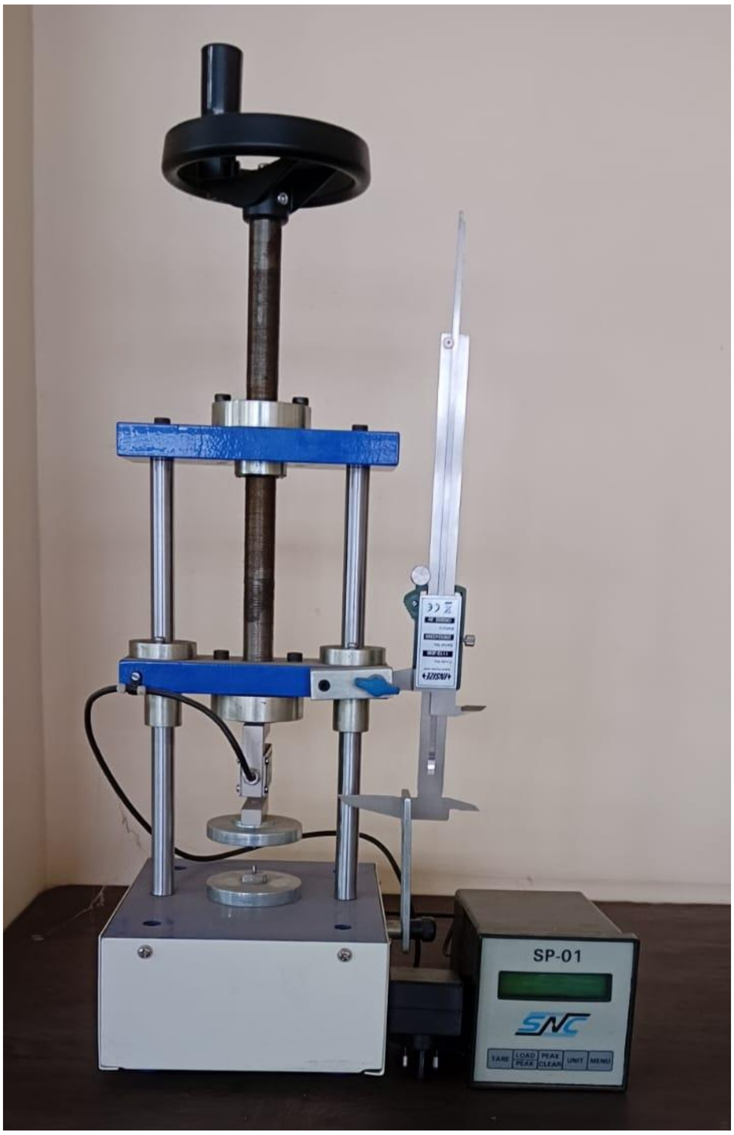

Fig. 2 The Spring Stiffness Tester

Fig. 3 The Muffle Furnace

8 Results and Discussion

In thus section, the results of the experiments detailed in Section 7.1 are presented and discussed. Salient observations were made and conclusions are drawn after the completion of stages of experiments. The results and discussions related to the stages of experiments performed as outlined in Subsections 7.1.1, 7.1.2 and 7.1.3 are presented below:

8.1 Initial Results of Sound Measurement with Application of Surface Coating

Using the initial five pairs of ratchet wheel-plunger, each coated with a different coloured coating, sound level measurements were conducted were conducted with the components fitted into the gun mechanism in INSAS MARK 1 with Butt No. 458. Measurements were taken at fixed distances of 0 m, 1 m, 2 m and 3 m from the source. For each configuration, five sound level (dB) readings were recorded during the locking and unlocking operations using a mobile app-based dB meter. It is noted that the app-based dB meter can be calibrated to read a base sound level of 0 dB. The mechanism was operated by personnel from the 68 Engr. Regt. of the Indian Army, Solmara Camp, and the trial tests were conducted at the Army camp stationed at Solmara. Although the room was not soundproof, efforts were made to maintain a quiet environment during the measurements. For comparison, the mechanism with uncoated ratchet wheel-plunger pair was also measured. The results obtained from these tests are summarized in Tables 1 to 6.

Table 1 Sound measurement **without coating** (using Android-based App)

Radial Distance (m)	Measurements (dB)					
	1	2	3	4	5	Average value
0	43	43	44	45	46	44.2
1	31	27	27	28	29	28.4
2	17	14	16	17	17	16.2
3	9	11	12	12	14	11.6

Table 2 Sound measurement with **green-coated** pairs of ratchet wheel-plunger (Sample 1) (using Android-based App)

Radial Distance (m)	Measurements (dB)						
	1	2	3	4	5	Average value	% reduction
0	38	37	36	39	41	38.2	13.57
1	23	23	24	20	20	22	22.54
2	15	14	14	16	17	15.2	6.17
3	11	10	11	9	10	10.2	12.07

Table 3 Sound measurement with **black-coated (smooth)** pairs of ratchet wheel-plunger (Sample 2) (using Android-based App)

Radial Distance (m)	Measurements (dB)						
	1	2	3	4	5	Average value	% reduction
0	32	31	31	30	31	31	29.86
1	15	13	12	12	12	12.8	54.93
2	10	11	10	9	9	9.8	39.51
3	6	5	5	7	5	5.6	51.72

Table 4 Sound measurement with **matt black-coated (rough)** pairs of ratchet wheel-plunger (Sample 3) (using Android-based App)

Radial Distance (m)	Measurements (dB)						
	1	2	3	4	5	Average value	% reduction
0	29	30	30	30	31	30	32.13
1	10	11	13	14	13	12.2	57.04
2	6	5	5	9	5	6	62.96
3	2	1	2	2	3	2	82.76

Table 5 Sound measurement with **grey-coated** pairs of ratchet wheel-plunger (Sample 4) (using Android-based App)

Radial Distance (m)	Measurements (dB)						
	1	2	3	4	5	Average value	% reduction
0	9	9	10	10	12	10	77.38

1	0	0	0	0	0	0	100.00
2	0	0	0	0	0	0	100.00
3	0	0	0	0	0	0	100.00

Table 6 Sound measurement with **white-coated** pairs of ratchet wheel-plunger (Sample 5) (using Android-based App)

Radial Distance (m)	Measurements (dB)						
	1	2	3	4	5	Average value	% reduction
0	18	19	22	18	20	19.4	56.11
1	0	0	0	0	0	0	100.00
2	0	0	0	0	0	0	100.00
3	0	0	0	0	0	0	100.00

As per a telephonic conversation with the coating supplier, Mr. Sandeep Soley of Dazzle Dyna Coat, the base material for the coatings used in Samples 1 to 4 was either fluorocarbon or nylon, while the coating for Sample 5 (white) consisted of a mixture of aluminium and manganese powder. No further chemical composition or thickness details were provided.

The salient observations made from the results presented in Tables 1–6 are as follows:

- The grey sample (Sample 4) provided the maximum reduction of 77.38% in sound with respect to the uncoated samples at zero-meter distance from the gun. At 1 m distance and higher, we attained 100% reduction in sound.
- The white sample (Sample 5) followed a similar trend albeit with a maximum sound reduction of 56.11% at zero-meter distance from the gun.
- There were encouraging results with the other three coated samples as well, but with moderate reduction in sound.

Based on conclusions drawn from the initial trial experiments, it was observed that the coatings with grey and white colour codes demonstrated the highest sound attenuation performance among the five coatings provided by the supplier. A moderate level of sound reduction was also noted with the matt black coating. Consequently, for the next phase of experimentation, grey, white, and matt black coatings were selected. Corresponding samples were sent to the coating service provider, along with a request to apply coatings of varying thicknesses ranging from 50 µm to 80 µm, and to disclose the detailed chemical compositions. However, determining the permissible range of coating thicknesses proved challenging due to the absence of detailed component assembly drawings specifying tolerance limits. The selected range was thus estimated based on the approximate thickness values initially shared by the coating service provider for the grey and white coatings.

Upon receiving the new set of samples, it was found that they were marked only with sample numbers, with no accompanying data on thickness or composition. These samples were selected for further sound level testing using the INSAS MARK 1 rifle. The experiments were conducted in a quiet room at the Dean’s Building, School of Engineering, Tezpur University, specifically, the lecture recording MIC room owing to its controlled acoustic environment. For this phase of testing, a precision sound level meter (Make: Casella), as specified in Section 7.2 was employed. A preliminary check with this instrument confirmed that the background noise level in the MIC room was within the range of 30 to 35 dB. The sound tests were then carried out in that room with the assistance of the DRL, Tezpur team, in coordination with Indian Army personnel stationed at Solmara Army Camp, Tezpur. This time the army personal carried INSAS MARK 1, Butt Nos. 191 and 192 for testing mechanism sound. Total ten numbers of readings were taken at 0 m distance from the source. The results of the tests conducted with uncoated and grey-coated ratchet wheel-plunger pairs are summarized in Tables 7 and 8.

Table 7 Sound measurement using uncoated ratchet wheel-plunger pair (using class 1 sound level meter in a room with controlled base level noise)

INSAS MARK 1 Gun, Butt No. 191		
Uncoated Ratchet wheel-plunger pair		
Reading no.	Measurement (dB)	Average value (dB)
1	58.7	64.43
2	61	
3	68.1	
4	67.9	
5	66.3	
6	67.3	
7	57.1	
8	70.2	
9	67.1	
10	60.6	
10	59.2	

Table 8 Sound measurement using grey-coated ratchet wheel-plunger pair (using class 1 sound level meter in a room with controlled base level noise)

INSAS MARK 1 Gun, Butt No. 191					
Gray coated Ratchet wheel-plunger pair: Sample 1			**Gray coated Ratchet wheel-plunger pair: Sample 2**		
Reading no.	Measurement (dB)	Average value (dB)	Reading no.	Measurement (dB)	Average value (dB)
1	63.2	59.36	1	62.2	61.75
2	62.9		2	61	
3	72.4		3	53.2	
4	60.5		4	67.6	
5	72.7		5	66.9	
6	75		6	60.2	
7	61.7		7	61.1	
8	64.2		8	60.2	
9	63.3		9	62.9	
10	59.2		10	62.2	
Gray coated Ratchet wheel-plunger pair: Sample 3			**Gray coated Ratchet wheel-plunger pair: Sample 4**		
Reading no.	Measurement (dB)	Average value (dB)	Reading no.	Measurement (dB)	Average value (dB)
1	71.2	68.23	1	63.2	65.51
2	65.7		2	62.9	
3	71.1		3	72.4	
4	70.2		4	60.5	
5	69.4		5	72.7	
6	57.9		6	75	
7	74.9		7	61.7	
8	69.1		8	64.2	
9	69.8		9	63.3	
10	63		10	59.2	

Upon comparing the sound level (dB) measurements for the uncoated configuration (as shown in Table 7) with those for the grey-coated samples (Table 8), it was observed that the sound attenuation performance was unsatisfactory. Specifically, Sample 1 with grey coating exhibited only a marginal average reduction of 7.87% in sound level relative to the uncoated ratchet wheel-plunger pair. For Sample 2, the reduction was even less significant, at just 4.16%. On the other hand, Samples 3 and 4 showed an increase in sound level when compared to the uncoated case. These findings are inconsistent with the earlier promising results obtained in the initial experiments (refer Table 5), where the grey coating demonstrated better sound attenuation. Thus, it was assumed that this discrepancy may be due to reduced coating thicknesses in the current samples, as compared to those used in the initial phase.

Given the unsatisfactory outcomes with the current grey-coated samples, it was then proceeded to test Sample 2 of the matt black-coated ratchet wheel-plunger pair and the results are presented in Table 9. However, this sample also failed to deliver any noticeable sound reduction. Following a visual inspection, the remaining matt black-coated samples were not considered for further testing. Subsequently, attention turned to a white-coated sample (Sample 1) and the previously tested grey-coated sample from the initial experiment set (refer Table 5). Results from these tests are presented in Table 10. Unfortunately, no sound reduction was observed with the current white-coated Sample 1, and only a modest 4% reduction was recorded with the earlier grey-coated sample.

Table 9 Sound measurement using matt black-coated ratchet wheel-plunger pair (using class 1 sound level meter in a room with controlled base level noise)

INSAS MARK 1 Gun, Butt No. 191		
Matt Black-coated Ratchet wheel-plunger pair: Sample 2		
Reading no.	Measurement (dB)	Average value (dB)
1	57.3	64.34
2	64	
3	66.6	
4	55.6	
5	71.6	
6	67.2	
7	63.6	
8	66.7	
9	62.1	
10	68.7	

Table 10 Sound measurement using current white-coated and old grey-coated ratchet wheel-plunger pair (using class 1 sound level meter in a room with controlled base level noise)

For Butt N0-191					
White-coated Ratchet wheel-plunger pair: Sample 1			**Old grey-coated Ratchet wheel-plunger pair (Ref Table 5)**		
Reading no.	Measurement (dB)	Average value (dB)	Reading no.	Measurement (dB)	Average value (dB)
1	66.4		1	56.6	
2	59.2		2	55.7	

3	68.1	63.91	3	66.9	61.79
4	58.6		4	64.9	
5	72		5	63.3	
6	56.1		6	65.7	
7	61.5		7	56.7	
8	68.6		8	62	
9	70.4		9	54.1	
10	58.2		10	72	

Table 11 Sound measurement using current white-coated and old grey-coated ratchet wheel-plunger pair (using class 1 sound level meter in a room with controlled base level noise)

For Butt N0-192					
Uncoated Ratchet wheel-plunger pair			**Old grey-coated Ratchet wheel-plunger pair (Ref Table 5)**		
Reading no.	Measurement (dB)	Average value (dB)	Reading no.	Measurement (dB)	Average value (dB)
1	61.1	67.45	1	57.9	67.25
2	78.3		2	69	
3	68.7		3	62.9	
4	79		4	80.9	
5	66		5	57.5	
6	51.7		6	74.2	
7	73		7	59.5	
8	61.9		8	80.2	
9	70.8		9	49.2	
10	64		10	81.2	

Given the consistent lack of improvement in sound attenuation across all current samples, including the previously successful, grey-coated sample, the investigators suspected potential inconsistencies with the test equipment, particularly the gun. It was noted that the recent tests were not conducted on the same INSAS MARK 1 gun used in earlier trials. To verify this, a different INSAS MARK 1 gun, with butt number 192, was used for testing both uncoated and the old, grey-coated samples. The results, summarized in Table 11, revealed no sound reduction with this gun either. This led to two possible conclusions: either there was a measurement error in the initial experiments (Tables 1–6), likely due to the use of a mobile app-based dB meter lacking precision, or the coating service provider had not applied sufficient coating thickness during the current sample preparation.

In view of the above conflicting observations with the coated pairs of ratchet wheel and plunger and inadequate number of left-over uncoated pairs (3 nos.), it was planned to proceed with the alternate route of reducing the sound through modifying the spring stiffness by heat treatment.

8.2 Results of Sound Measurement with Modified Spring Stiffness Through Heat Treatment

Initially, the stiffness of the as-received springs was measured for ten samples using a Spring Stiffness Tester (Make: Systems and Controls), as detailed in Section 7.2. Subsequently, each spring was heat treated at a different temperature ranging from 250°C to 600°C using the Muffle Furnace described in Section 7.2. Following heat treatment, the stiffness of each spring was measured again to reveal any changes caused by the thermal treatment. The results of the spring stiffness measurements before and after heat treatment are summarized in Table 12.

Table 12 Summary of the spring stiffness test before and after heat treatment

	Before Heat Treatment		**After heat treatment**			**% Reduction in stiffness**
	Length (mm)	**Stiffness (N/mm)**	**Temperature (°C)**	**Length (mm)**	**Stiffness (N/mm)**	
Spring 1	13.5	3.53	250	13.38	3.49	1.13
Spring 2	14	3.39	300	13.80	3.56	−4.77
Spring 3	13.68	3.45	350	13.50	3.66	−6.08
Spring 4	13.60	3.05	400	Distorted	Distorted	-
Spring 5	13.64	3.41	400	13.60	3.64	−6.31
Spring 6	13.78	3.70	450	13.64	3.66	1.08
Spring 7	13.52	3.54	500	12.20	2.82	20.34
Spring 8	13.74	3.54	550	Distorted	Distorted	-
Spring 9	13.76	2.62	550	13.64	2.60	0.76
Spring 10	13.84	3.32	600	Distorted	Distorted	-

From Table 12, it is observed that the stiffness of the as-received springs varied between 2.62 and 3.54 N/mm. The most significant reduction in spring stiffness occurred in Spring 7, which decreased from 3.54 N/mm to 2.82 N/mm after heat treatment at 500 °C, representing a

20.34% reduction. The next highest reductions were observed in Spring 10 (12.05%) and Spring 8 (5.08%). For the remaining springs, either negligible or no change in stiffness was recorded following heat treatment. In general, heat treatments at temperatures below 450 °C did not result in noticeable changes in stiffness. However, treatments at 450 °C or above led to a reduction in stiffness, particularly for springs with initial stiffness values of 3.32 N/mm or higher. It is worth noting that Spring 9, which exhibited the lowest initial stiffness of 2.62 N/mm, showed almost no change even after being subjected to heat treatment at 550 °C. Spring 4 was found to be distorted post-heat treatment. This distortion may be attributed to material inhomogeneity or thermal buckling effects.

Next, the heat-treated springs were installed in the safety mechanism of the INSAS MARK 1 rifle (butt number 458), using the uncoated ratchet wheel-plunger pair for locking and unlocking operations. Sound level tests were then conducted. It was found that Springs 5, 7, and 9 resulted in significant sound reduction during operation. On the other hand, the remaining springs resulted only marginal improvements. The results of the sound level measurements for the best-performing Springs 5, 7, and 9 are presented in Table 13. The sound reduction observed with Spring 7 is attributed to a decrease in its stiffness due to heat treatment. On the other hand, the reduction achieved with Springs 5 and 9 is likely due to a decrease in their lengths after heat treatment, as no significant change in stiffness was observed in these two springs.

Table 13 Sound level measurements with the uncoated ratchet wheel-plunger pair and heat treated Springs 5, 7 and 9 (using class 1 sound level meter in a room with controlled base level noise)

Measured Sound Level (dB)			
	Spring 5	**Spring 7**	**Spring 9**

Reading No.	Before Heat Treatment	After heat treatment at 400 °C with uncoated ratchet wheel-plunger pair	Before Heat Treatment	After heat treatment at 500 °C with uncoated ratchet wheel-plunger pair	Before Heat Treatment	After heat treatment at 550 °C with uncoated ratchet wheel-plunger pair
1	82.60	63.90	62.10	50.30	75.60	42.60
2	79.0	70.50	67.70	54.40	66.00	51.20
3	73.10	59.60	69.50	54.40	66.10	52.30
4	79.40	67.70	62.30	51.30	70.50	58.90
5	67.50	61.10	70.40	63.30	65.20	44.60
6	82.30	55.00	72.80	51.90	65.80	49.60
7	75.00	66.70	70.40	60.40	74.30	46.60
8	74.90	56.20	72.90	59.40	63.10	58.90
9	79.10	66.60	67.40	55.90	74.00	41.60
10	72.40	63.70	73.10	51.60	62.70	50.90
Average	**76.53**	**63.10**	**68.86**	**55.29**	**68.33**	**49.72**
% reduction		**17.54**	**-**	**19.71**	**-**	**27.23**

It is observed from Table 13 that, among the best-performing springs, Spring 9 achieved the maximum sound reduction of 27.23%. These results were subsequently reported to DRL, Tezpur, which then proposed conducting a combined study to investigate the combined effects of surface coating and changes in spring characteristics.

8.3 Combined Effect of Coating and Heat-Treated Spring

Based on the proposal from DRL, Tezpur, to investigate the combined effects of surface coating and changes in spring characteristics, an online meeting was convened by the Director, DRL. The meeting was attended by the PI, the associated scientist from DRL, Dr. Ananta Saikia, and Mr. Soley from Dazzle Dyna Coat, the designated coating service provider. The agenda of the meeting was to discuss the coating of the required number of ratchet wheel-plunger pairs for the proposed investigation. During the meeting, Mr. Soley agreed to coat the required number of samples. The PI reported that only three uncoated samples were remaining. Consequently, the Director, DRL, recommended submitting a formal request to the Indian Army through proper channel for additional uncoated samples. Although the request was processed through DRL, Tezpur to HQ 4 Corps, Indian Army for additional spare parts (20 Nos each of Rachet wheel and Plunger), they could not provide the same due to some technical problems. In view of this limitation, the PI and Co-PI decided to proceed with the three remaining uncoated samples. To discuss the coating specifications for these samples, another online meeting was held involving the DRL scientist Dr. Saikia, the PI and Co-PI of the project, and Mr. Soley. During this meeting, the PI and Co-PI requested Mr. Soley to apply a grey coating to the three samples with thicknesses of 80 μm, 100 μm, and 120 μm, respectively. Mr. Soley agreed and requested that the samples be sent to him. The samples were sent in May 2025 and were received back by the investigators in July 2025. However, the coated samples were not labelled with the specified thicknesses as requested. Instead, they were returned labelled simply as Set I, II, and III, following the previous naming convention. The coated samples are shown in Fig. 4. A few photographs taken during the experiments are shown in Figs. 5-7.

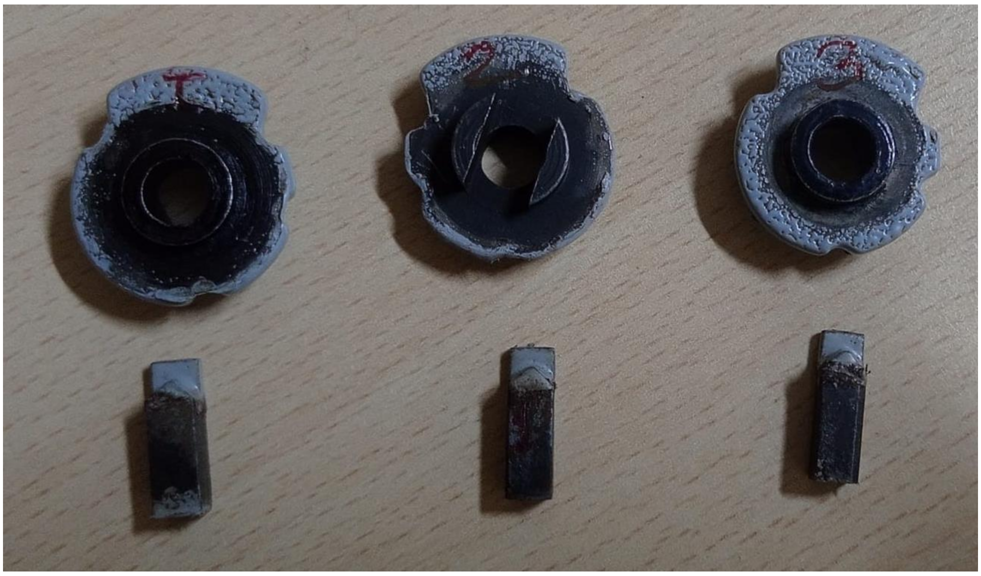

Fig. 4 The grey-coated samples for the final phase of experiments

Upon receipt of the newly coated samples, sound level tests were performed using the original INSAS MARK 1 gun (butt number 458) to maintain consistency in measurement. These tests were conducted at Tezpur University in a limited-controlled acoustic environment, with a base ambient noise level of approximately 30 dB. The sound measurements for all three coated sets were recorded at distances of 0 m, 1 m, 2 m, and 3 m from the sound source *i.e*., the gun's safety mechanism, and the results are presented in Table 14. The objective of the tests was to identify the best pair of coated ratchet wheel and plunger offering the highest sound attenuation.

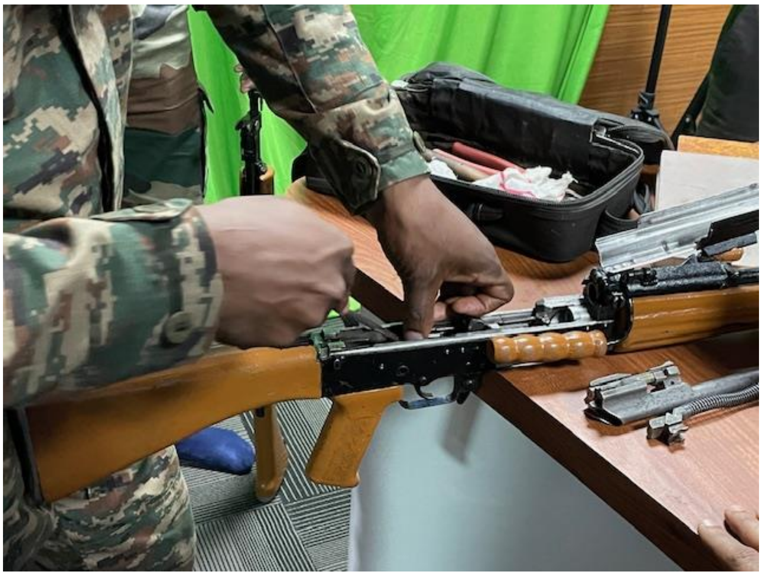

Fig. 5 Assembling of the locking-unlocking mechanism

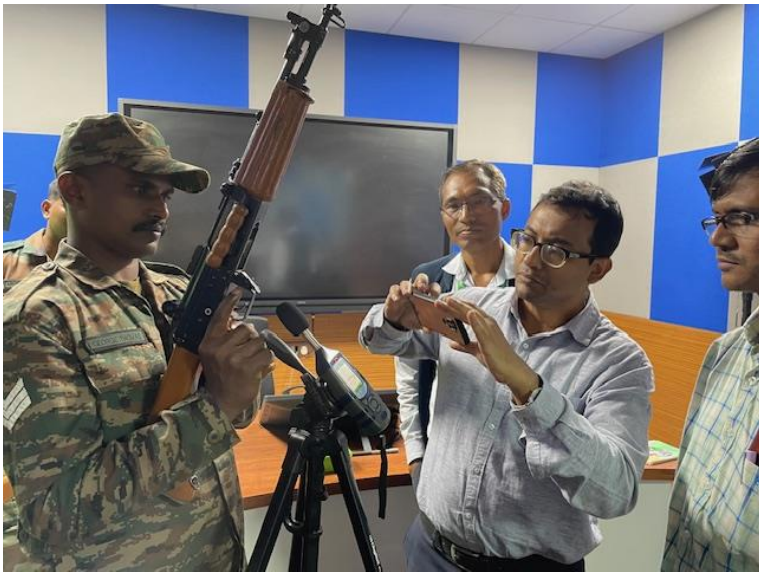

Fig. 6 Sound measurements during locking and unlocking operations

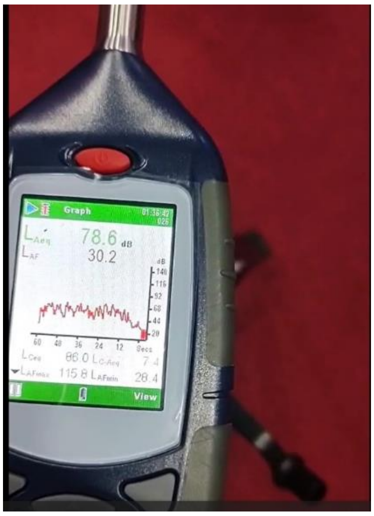

Fig. 7 Display of instantaneous sound level on the dB meter

Table 14 Comparative sound level measurement with the latest grey-coated ratchet wheel-plunger pairs (to identify the best pair) (using class 1 sound level meter in a room with controlled base level noise)

Butt No. 458												
Reading No.	**Measured Decibel (dB)**											
	Latest grey-coated ratchet and plunger set I				**Latest grey-coated ratchet wheel-plunger set II**				**Latest grey-coated ratchet and plunger set III**			
	0 m	**1 m**	**2 m**	**3 m**	**0 m**	**1 m**	**2 m**	**3 m**	**0 m**	**1 m**	**2 m**	**3 m**
1	61.4	47.0	43.7	42.2	40.2	32.0	31.4	33.3	50.7	52.7	44.3	42.4
2	58.5	41.5	43.2	45.3	58.3	51.5	45.3	44.5	41.4	43.3	41.8	32.8
3	64.0	41.1	50.3	37.2	40.8	32.4	32.4*	32.7	46.8	43.3	42.1	48.3
4	53.6	51.2	42.1	46.1	67.2	41.0	41.7	39.0	37.7	33.4	36.3	33.6
5	59.5	50.0	44.5	40.4	41.7	31.3*	32.4*	32.3	56.8	49.1	38.6	41.8
6	65.0	52.1	49.9	37.9	59.9	51.8	44.8	40.4	41.7	35.1	35.5	32.7
7	58.0	45.7	50.6	43.8	46.0	35.7	32.4*	35.9	51.2	41.9	52.5	48.1
8	66.4	43.5	44.3	41.0	56.8	53.5	43.6	40.3	51.2	46.9	39.1	38.3
9	62.4	41.8	42.2	45.1	35.3	32.7	33.1*	33.4	50.8	47.9	51.3	35.8
10	59.0	47.0	45.7	48.0	57.0	54.4	37.6	38.4	39.9	44.9	45.0	36.2
Average	**60.78**	**46.09**	**45.65**	**42.70**	**50.32**	**41.63**	**37.47**	**37.02**	**46.82**	**43.85**	**42.65**	**39.00**

*Base noise level

From Table 14, it is observed that for a given spring, Set III of the grey-coated ratchet wheel and plunger exhibit the highest sound reduction. Accordingly, all subsequent sound measurements were carried out using Set III in combination with the heat-treated springs. Since Springs 5, 7, and 9 demonstrated significant sound reduction after heat treatment, as shown in Table 13, these springs were selected for further testing. The results of the sound level measurements using Set III in combination with Springs 5, 7, and 9 are presented in Tables 15–17. Measurements were taken at fixed distances of 0 m, 1 m, 2 m, and 3 m from the sound source using butt no. 458 of INSAS MARK 1 gun. The results were then compared with those obtained from two other configurations: (i) untreated springs with uncoated ratchet wheel-plunger sets, and (ii) heat-treated springs with uncoated ratchet wheel-plunger sets.

Table 15 Sound level measurement with heat treated spring 5 combined with the latest grey coated ratchet wheel-plunger Set III (using class 1 sound level meter in a room with controlled base level noise)

SPRING 5						
Reading No.	**Measured Sound Level (dB)**					
	Before Heat Treatment with uncoated ratchet wheel and plunger set (at 0 m distance)	**After heat treatment at 400 °C with uncoated ratchet wheel and plunger Set (at 0 m distance)**	**After heat treatment at 400 °C with latest grey-coated ratchet and plunger set III**			
			0 m	**1 m**	**2 m**	**3 m**
1	82.60	63.90	50.8	45.9	49.9	48.3
2	79.0	70.50	63.8	46.7	40.6	41.8
3	73.10	59.60	67.3	55.4	41.2	36.1
4	79.40	67.70	62.3	45.2	46.3	43.5
5	67.50	61.10	55.7	53.1	43.0	40.7
6	82.30	55.00	55.7	50.0	40.8	45.1

7	75.00	66.70	59.2	57.4	53.1	40.0
8	74.90	56.20	50.8	51.6	50.4	35.2
9	79.10	66.60	57.3	58.2	43.8	35.7
10	72.40	63.70	60.6	56.6	51.8	42.3
Average	**76.53**	**63.10**	**58.35**	**52.01**	**46.09**	**40.87**
% reduction		**17.54**	**23.76**	**32.04**	**39.78**	**46.60**

Table 16 Sound level measurement with heat treated spring 7 combined with the latest grey coated ratchet wheel-plunger Set III (using class 1 sound level meter in a room with controlled base level noise)

SPRING 7						
Reading No.	**Measured Sound Level (dB)**					
	Before Heat Treatment with uncoated ratchet wheel and plunger set (at 0 m distance)	**After heat treatment at 500 °C with uncoated ratchet wheel and plunger Set (at 0 m distance)**	**After heat treatment at 500 °C with latest grey-coated ratchet and plunger set III**			
			0 m	**1 m**	**2 m**	**3 m**
1	62.10	50.30	50.3	42.9	46.4	35.7
2	67.70	54.40	48.6	48.3	31.6	31.7
3	69.50	54.40	56.8	49.1	35.0	42.1
4	62.30	51.30	50.3	41.2	34.0	33.5
5	70.40	63.30	53.1	44.8	37.9	42.2
6	72.80	51.90	50.5	40.4	40.1	37.4
7	70.40	60.40	47.6	50.1	45.9	41.2
8	72.90	59.40	49.8	40.6	39.2	31.1
9	67.40	55.90	58.7	50.7	48.9	32.0

10	73.10	51.60	39.9	36.6	39.0	37.4
Average	**68.86**	**55.29**	**50.56**	**44.47**	**39.8**	**36.43**
% reduction		**19.71**	**26.58**	**35.42**	**42.20**	**47.10**

Table 17 Sound level measurement with heat treated spring 9 combined with the latest grey coated ratchet wheel-plunger Set III (using class 1 sound level meter in a room with controlled base level noise)

SPRING 9						
Reading No.	**Measured Sound Level (dB)**					
	Before Heat Treatment with uncoated ratchet wheel and plunger set (at 0 m distance)	**After heat treatment at 550 °C with uncoated ratchet wheel and plunger set (at 0 m distance)**	**After heat treatment at 550 °C with latest grey-coated ratchet and plunger set III (Date- 14/07/2025)**			
			0 m	**1 m**	**2 m**	**3 m**
1	75.60	42.60	-	Sound is below base noise level	-	-
2	66.00	51.20				
3	66.10	52.30				
4	70.50	58.90				
5	65.20	44.60				
6	65.80	49.60				
7	74.30	46.60				
8	63.10	58.90				
9	74.00	41.60				
10	62.70	50.90				
Average	**68.33**	**49.72**	**-**			
% reduction		**27.23**	**-**			

It is observed from Tables 15–17 that the combined effect of surface coating treatment on the ratchet wheel and plunger, when used in conjunction with heat-treated springs, resulted in a further reduction in sound levels. Specifically, the average sound reduction at the source improved from 17.54% to 23.76% when heat-treated Spring 5 was used with Set III, compared to the untreated spring with the uncoated ratchet wheel-plunger set. For heat-treated Spring 7 with Set III, the reduction increased from 19.71% to 26.58%. In the case of heat-treated Spring 9 combined with Set III, the sound level was reduced to the base noise level of the room, indicating near-complete attenuation under the given test conditions. Prima facie, these findings indicate that the cumulative effect of surface treatment of the mating surfaces of the ratchet wheel and plunger, along with spring heat treatment, can achieve optimal sound reduction during the locking and unlocking operations of the safety mechanism.

Overall, the results obtained in this study provide a proof-of-concept for multiple approaches to sound attenuation in small-calibre guns. However, further detailed investigation is required to establish these methods conclusively. This includes optimization of various process parameters (such as coating thickness and compositions, and spring heat-treatment protocols, spring stiffness etc.) and geometrical design factors to achieve consistent performance.

9 Challenges and Limitations

The initial plan for the project was to explore the following routes for reduction of the sound level during the locking and unlocking operations of the INSAS Mark I guns:

- Surface coating on the mating surfaces of the ratchet wheel and plunger using compatible sound-absorbing materials of different compositions and thicknesses.
- Reduction of the spring stiffness
- Optimization of the tolerance between the ratchet wheel and the plunger in the engaged and disengaged positions to reduce the metal-to-metal impact velocity and sound level.

The major challenges faced during the execution of the project to implement the three routes were as follows.

i. It was found that installation of a mixer machine and spray coating set up for sophisticated coating applications would cost more than 20 lakhs, whereas it was advised by the funding agency to limit the total budget within 10 lakhs. Therefore, the PI and Co-PI had to find a suitable technical support service provider (TSSP) outside the RSP.

ii. After significant searching for a TSS provider, the PI and Co-PI could locate one coating expert on personal contact through a senior scientist from ARDE, Pune. The TSSP coated requested number of limited samples, but the did not disclose the coating thickness and the coating composition even after several repeated requests.

iii. The tolerance analysis required the part assembly drawings of the locking and unlocking mechanism of the gun with the allowable tolerance limits. Since the drawings could not be made available even after repeated attempts by the RSP and the associated lab, the plan to explore the third route was dropped.

iv. The Project Assistant recruited for the CARS was diagnosed with cancer in August 2024 and he expired in December 2024. The lack of support staff was a big challenge for the PI and Co-PI.

v. Since the expected sound level was less than 30 dB after the surface treatment of the ratchet wheels and plungers and the heat treatment of the springs, a controlled acoustic chamber was required for the experiments. The RSP explored the availability of such facilities in other Academic and R&D organizations but didn't succeed. The funding agency was also requested to arrange a facility in this regard. However, after several attempts such facility could not be found. In view this limitation, the sound measurements were performed in lecture recording rooms with limited noise control (having base level around 30 dB). In some cases the sound level with the surface treated samples and heat-treated springs went below the base level noise, which could not be detected.

vi. As the surface coating method could not be established with definite certainty of coating composition and coating thickness from the TSSP, it was proposed by the RSP to complete the CARS based on reduction of spring stiffness only. In an online meeting among the funding agency, the PI, and the TSSP on 18.01.2025, it was advised by the funding agency to further explore the possibility of sound reduction with more no. of coated samples along with the heat-treated springs. Accordingly, the funding agency requested to the Indian Army to issue more sets of ratchet wheel and plungers, as the RSP had only three sets of spare ratchet wheels and plungers in uncoated condition. However, the additional samples could not be received from the Indian Army even after waiting for sufficient time for their response. As time for the CARS was running out, it was decided to proceed with only the remaining three sets of uncoated samples for sending to the TSSP for coating.

vii. The precise measurements require to be done using class 1 sound level meters coupled with sophisticated data acquisition system in a controlled acoustic chamber.

In view of the challenges, the following are listed as the limitations of the current study.

i. The sound attenuation using the surface coating technique should be viewed a proof-of-concept demonstration.
ii. The spring-stiffness reduction technique through heat treatment exhibits the potential to effectively attenuate the sound level during the locking/unlocking operations of the guns. However, for establishing this hypothesis, sufficient no. of springs having consistent stiffness and dimensions before heat treatment should be made available, and experiments are to be performed under controlled acoustic environment with data acquisition systems using a number of springs heat treated at the same temperatures.

10 Conclusions

In spite of the challenged and limitations faces, the CARS with the title "Reduction of the sound level during the locking and unlocking operations of small-calibre guns" successfully demonstrated immense potential to reduce the sound level of INSAS Mark 1 guns. The following achievements of the CARS can be listed as the high points of the conclusions.

i. Coating thickness of the sound-absorbing material plays a role in reduction of the sound level during the locking and unlocking operation of the INSAS Mark 1 guns.
ii. The springs are available with the Indian Army at various stiffness values ranging from 2.62 N/mm to 3.70 N/mm, and at various lengths ranging from 13.5 mm to 14.0 mm before heat treatment.
iii. Heat treatment results in reduction of the spring length, that can reduce the compression of the spring, thereby reducing the sound caused by metal-to-metal impact during the locking and unlocking operations of the gun. However, heat treatment at temperatures at 300°C, 350°C, and 400°C caused marginal increase in spring stiffness.

iv. A spring (marked as Spring #9) with stiffness values of 2.62 N/mm and 2.60 N/mm before and after heat treatment at 550°C, respectively, produced a sound reduction of 27.23% with an uncoated ratchet wheel and plunger set. The corresponding spring lengths were 13.76 mm and 13.64 mm.

v. A spring (marked as Spring #7) with stiffness values of 3.54 N/mm and 2.82 N/mm before and after heat treatment at 500°C, respectively, produced a sound reduction of 19.71% with an uncoated ratchet wheel and plunger set. The corresponding spring lengths were 13.52 mm and 12.20 mm.

vi. A spring (marked as Spring #5) with stiffness values of 3.41 N/mm and 3.64 N/mm before and after heat treatment at 400°C, respectively, produced a sound reduction of 17.54% with an uncoated ratchet wheel and plunger set. The corresponding spring lengths were 13.64 mm and 13.60 mm.

vii. Three sets of ratchet wheel and plungers were received for the final experiments from the TSSP. These were marked as Set I, Set II and Set III. The three sets were tested on the same gun and same spring. It was found the sets I, II, and III resulted in average sound levels of 60.72 dB, 50.32 dB, and 46.82 dB, respectively, art 0 m distance from the locking mechanism. Henceforth, subsequent sound tests with the heat-treated springs #5, #7, and #9 were performed with coated ratchet wheel and plunger set III.

viii. With the coated set III, Spring #5 produced sound reduction of 23.76%, 32.04%, 39.78%, and 46.60% at 0 m, 1 m, 2 m, and 3 m distance, respectively from the locking mechanism.

ix. With the coated set III, Spring #7 produced sound reduction of 26.58%, 35.42%, 42.20%, and 47.10% at 0 m, 1 m, 2 m, and 3 m distance, respectively from the locking mechanism.

x. With the coated set III, Spring #9 produced sound below the base level noise of 30 dB in the experimental facility.

xi. The findings demonstrate the concept of reduction of sound level through coating of sound-absorbing materials on the mating surfaces of the ratchet wheel and plunger, and use of springs having lower stiffness values (2.6 N/mm to 2.8 N/mm) and spring length (12.20 mm to 13.60 mm).

Acknowledgement

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Appendix A

Calibration report of the Spring Stiffness Tester

CALIBRATION CERTIFICATE

CC-2287

Work Order No.	WO/M&V/214/23-24	Certificate No. :	CC/M&V/0698-0703/23-24
Work Order Date	05/10/2023	Date of Calibration :	09/10/2023
Date of Receipt :	05/10/2023	Date of Issue :	16/10/2023
ULR No. :	CC228723300001427F to CC228723300001432F		
Discipline :	Mechanical Calibration (Group: Mass & Volume)	Page No. :	1 of 2

Calibrated for : M/s. Systems & Controls.
C-15, MIDC Indl. Estate, Malegaon- Sinnar,
Dist: Nashik-4422103.

Calibrated at : IDEMI, Mumbai.

Description of Device Under Calibration	Standards Used for Calibration
Name :Brass Weights Manufacturer : Not Specified Condition of Item on receipt : Good Nominal Weights : 500g,1kg, 2kg, 5kg & 10kg Material : Brass ID.No. : Refer Page 2 of 2 Sr.No : Refer Page 2 of 2 Model. No : Not Specified Accuracy : Not Specified	1. Reference S.S.Weights E2 Class 500g to 10 kg ID No.: M&V/STD/E2/10 to 15 Calibration Certificate No : CC/M&V/2023-2028/22-23 Calibration Validity Up to : 17/02/2024 2. Digital Balance ID No.: M&V / STD / DB / 04 Calibration Certificate No : CC/M&V/2273/22-23 Calibration Validity Up to : 12/03/2024 3. Digital Balance ID No.: M&V / STD / DB / 05 Calibration Certificate No : CC/M&V/2274/22-23 Calibration Validity Up to : 12/03/2024 All measurement results are traceable to the International system of units (SI), ensured by comparison, directly or indirectly with National or International standards through unbroken chain of calibration

Ambient Conditions :

Temperature: 24.9 °C to 25.1°C Relative Humidity : 51 % to 53%

Barometric Pressure : 1007.2 mbar

Remarks : Please refer page 2 of 2 for Calibration Results.

1) Procedure of Calibration : Above mentioned item is calibrated as per operating procedure : OP : M&V : 002
2) The reported expanded uncertainty in measurement is stated as the combined standard uncertainty in measurement multiplied by the coverage factor k = 2, which for a normal distribution corresponds to a coverage probability of approximately 95 %.
3) Calibration Status : Sticker No.0698-0703 indicating 'CAL STATUS' is affixed on instrument.
4) The calibration certificate issued for weights used for scientific or industrial purpose only.
5) Our NABL Accreditation Certificate No. is CC - 2287, Valid up to 30/08/2025.
6) Next Calibration Due on : 08/10/2024

PRADEEP SHANTILAL GUJARATHI
Digitally signed by PRADEEP SHANTILAL GUJARATHI Date: 2023.10.16
AUTHORISED SIGNATORY

Note:

1. This certificate refers only to the particular item(s), submitted for calibration. The certificate should not be reproduced expect in full without the prior permission from the Principal Director, IDEMI, Mumbai - 400 022.
2. This is computer generated certificate and may not contain signature. Where send by email, this is signed with digital signature of authorized signatory, approved by NABL. For any queries, please quote work order number mentioned in this certificate

वैद्युतिक मापन उपयंत्र अभिकल्प संस्थान, मुंबई

INSTITUTE FOR DESIGN OF ELECTRICAL MEASURING INSTRUMENTS, MUMBAI

Government of India Society

Ministry of Micro Small & medium Enterprises

Swatantryaveer Tatya Tope Marg, Chunabhatti, Sion, P.O. Mumbai - 400 022

FF-LAB-003 Rev 01

Date of Calibration : 09/10/2023

Certificate No : CC/M&V/0698-0703/23-24

Calibration Results :

Denomination	Sr No	ID No	ULR No	Certificate No	Mass Value In (g)	Exp. Uncertainty in ± (g) at k =2
500g	S&C 500		CC228723300001427F	CC/M&V/0698/23-24	499.992	0.005
1kg		A	CC228723300001428F	CC/M&V/0699/23-24	1000.004	0.01
1kg		B	CC228723300001429F	CC/M&V/0700/23-24	995.408	0.01
2kg	S&C 2000		CC228723300001430F	CC/M&V/0701/23-24	1999.969	0.02
5kg	S&C 5000		CC228723300001431F	CC/M&V/0702/23-24	4998.377	0.05
10kg	S&C 10000		CC228723300001432F	CC/M&V/0703/23-24	10001.79	0.1

Remark :

1. Above readings represent mean of five readings.
2. Weights are calibrated as per ther customer's requirment.

Appendix B

Detailed Technical Specifications and Calibration Report of the Sound Level Meter

Technical Specification

Applicable Standards:

IEC 60651 - 1979	Octave filters (CEL-620 B, C & D Models only):
IEC 60804 - 2000	IEC 61260 Class 0
IEC 61672 - 2013	ANSI S1.11-2004
ANSI S1.4 - 1983 (R2006)	NPL India Certified
ANSI S1.43 - 1997 (R2007)	

Technical:

Total measurement range:	20 to 140dB RMS (single range),143.0 dB Peak 25 to 165db RMS (single range) with MIC1
Frequency weightings RMS:	Simultaneous A, C & Linear (Z)
Frequency weightings Peak:	Simultaneous A, C & Linear (Z)
Time weightings:	Simultaneous Slow, Fast & Impulse (35ms)
Amplitude weightings:	Q3, Q4 and Q5 (Q4 & Q5 applicable to L_{avg} only)
Thresholds:	70 to 90 (dB) in 1 dB steps (applicable to L_{avg} only)
Noise floor:	19dB(A) Class 1, 25dB(A) Class 2
Display:	320x240 pixel transmissive colour with update period of 0.5 seconds
Frequency response:	6Hz to 20kHz
Calibration:	Stores pre and post run calibration date, time and level
Output (P.C.):	USB 2.0 'A' to 'Mini B'
Batteries:	3 x AA Alkaline (8 - 12 hours depending on backlight
External power:	9-14V DC at 250mA via 2.1mm connector
Tripod mount:	1/4" Whitworth socket
Size mm (in):	72 x 229 x 31mm (2.8 x 9.0 x 1.2")
Weight gm (oz):	295g (10.4oz)
Memory:	Micro SD 2GB/4GB/8GB Non Volatile Internal
Runs Stored:	999 (Password Protected)
Resolution:	0.1dB display resolution
GPS (Optional):	Inbuilt (Non-Removable)
Audio Recording:	Optional
Low quality:	8000 samples @ 8bit (74kb/s) up to 4kHz
High quality:	24000 samples @8bit (192kb/s) up to 12 kHz
On/Off timers:	6 sets with selectable times and a repeat function
Microphone:	1/2" pre-polarised back electrate (50mv/Pa)
Accuracy:	+/- 0.7dB (Class 2), +/- 0.2dB (Class 1)

Other (Optional) Accessories

TGP	Thermal Graphic Printer Kit Softland Iprint marvel
DMP	Dot Matrix Printer Kit Softland Iprint marvel DMP
CLE-6718	Lightweight tripod
CEL-251	Microphone Class 1
CEL-252	Microphone Class 2
PC18	Universal power supply
CMC51	USB download cable
MIC1	1/4" High Range Microphone (25 to 165 dB)
MPA1	High Range Microphone Adaptor (for use with MIC1)
POW1	external rechargeable power pack for back up more than 24 hours
SCC	Soft Carry Case
HCC	Hard Carry Case
ADL	Android device Lite
ADP	Android device Palm with thermal printer

Note : CEL-620 XY/K

X Denotes - Model type A (Broad Band), B(Octave Band), C (1/3 Octave & Octave Band), D with Advanced features with optional android

Y Denotes - For Class 1 or Class 2

K Denotes - Kit along with optional selected accessories

Ordering Information

CEL-620A1/K	Class 1 Sound Level Meter Kit
CEL-620B1/K	Octave Band Class 1 Sound Level Meter Kit
CEL-620C1/K	1/3rd Octave Band Class 1 Sound Level Meter Kit with bluetooth & Wifi (Optional)
CEL-620D1/K	Precision Integrating Octave Band Sound Level Meter (Class 1). Compatible with Palm Pilot (Android) for WiFi/4G Data transfer (Optional)

All instruments and calibrators are provided with calibration certificates.

Instrument Kits

Complete kit options are available with sound level meter, acoustic calibrator (CEL-120), soft/hard carry case, windshield, instruction manuals, USB Cable, Insight data management software, Do Matrix/Thermal Printer, Printer Cable, 4AA Rechargeable Cell & Charger.

Insight

Management Software

Casella Insight data management software is a powerful yet simple tool to download, analyse and report form either workplace or environmental noise date.

- Analysis of noise level time history
- Replay voice notes and event audio
- Intuitive user interface
- Remove anomalous date from results
- Analysis of time history
- Generate comprehensive reports
- Store data by, person, place, location
- Manage multiple Instruments and calibration
- Connectivity windows 7 or better

Printer Key Features:

- BIS Approved
- Internal Storage
- Strong Bettery Backup
- Rechargable

Measured Parameters:

CEL-620A: L_{XY}, L_{XYmax}, L_{XYmin}, L_{Xeq}, L_{Xpeak}, L_{avg}, L_C-L_A, L_{XIeq}, L_{TM3}, L_{TM5}, L_{AE}, L_{10}, L_{50}, L_{90}

CEL-620B: L_{XY}, L_{XYmax}, L_{XYmin}, L_{Xeq}, L_{Xpeak}, L_{avg}, L_C-L_A, L_{XIeq}, L_{TM3}, L_{TM5}, L_{AE}

Octaves: L_{XY}, L_{XYmax}, L_{Xeq}

Where X is the frequency weighting A, C or Z and Y represents time weighting Fast (F), Slow (S) or Impulse (I).
All weightings simultaneously measured where appropriate.

Environmental:

In Operation	Relative humidity of 5% to 90% (non-condensing) Temperature-10 to 50°C Atmospheric pressure of 65 to 108kPa
In Storage	0 to 90%RH in the absence of condensation Temperature-20 to 60°C Atmospheric pressure of 65 to 108kPa

सी एस आई आर – राष्ट्रीय भौतिक प्रयोगशाला
CSIR-NATIONAL PHYSICAL LABORATORY
(वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद)
(Council of Scientific and Industrial Research)
(राष्ट्रीय मापिकी संस्थान (एनएमआई), सदस्य बीआईपीएम एवं हस्ताक्षरकर्ता सीआईपीएम – एमआरए)
(National Metrology Institute (NMI), Member BIPM and Signatory CIPM - MRA)
डॉ. के. एस. कृष्णन मार्ग, नई दिल्ली–110012, भारत
Dr. K. S. Krishnan Marg, New Delhi-110012, INDIA
दूरभाष/Phone : 91-11-4560 8441, 8589, 8610, 9447, फैक्स/ Fax : 91-11-4560 8448
ई–मेल/ E-mail : cfct@nplindia.org, वेबसाईट/ Website : www.nplindia.org

अंशांकन प्रमाण पत्र
CALIBRATION CERTIFICATE

SOUND LEVEL METER

प्रमाण पत्र संख्या/ Certificate No.
23090873/D1.07/C-127

दिनांक/ Date	अगले अंशांकन हेतु अनुशंसित तिथि Recommended date for the next calibration	पृष्ठ/ Page	पृष्ठों की संख्या / No. of Pages
16-10-2023	16-10-2025	1	2

1. Calibrated for	:	M/s TSI Instruments India Private Limited Office No- 1203, 12th Floor, Eros Corporate park, IMT Manesar, Gurugram Haryana – 122 050 Customer Reference: Nil dated 28/09/2023
2. Description and Identification of Item	:	**Casella Sound Level Meter, Type: CEL-620 C1/IP S. No. 4784196**
3. Environmental Conditions	:	Room Temperature : (23.0 ± 5.0) °C Relative Humidity : (50.0 ± 15.0) % RH Atmospheric Pressure : 98.5 kPa
4. Standard used and Associated Uncertainty	:	Standard Condenser Microphone, B&K 4180 S. No. 1863694, **± 0.05 dB to ± 0.11 dB** in frequency range **31.5 Hz to 10 kHz.**
5. Traceability of Standards used	:	The standard(s) used for calibration is (are) traceable to the National Standard, which realize the units of quantities according to the International System of Units (SI).
6. Principle/ Methodology of Calibration & Calibration Procedure No.	:	Comparison with Reference Standard, **Sub-Div. # 1.07/Doc. 3/CP # 04**

7. **Results**

As requested by the party, the sound level meter was calibrated for the following parameters under existing laboratory conditions.

1. **Deviation from the Indicated level**

The sound level meter along with its microphone was calibrated for deviations from indicated level at the reference frequency of **1000 Hz** and reference sound pressure level of **94.0 dB.**

The observed sound level meter readings was **94.1 dB(A).** The deviation of the test sound level meter from the indicated value was **0.1 dB for A- weighting.**

अंशांकनकर्ता Calibrated by : (DR. CHITRA GAUTAM)

जाँचकर्ता Checked by : (DR. NAVEEN GARG)

जारीकर्ता Issued by :

प्रभारी वैज्ञानिक Scientist-in-charge : (DR. NAVEEN GARG)

2. Frequency Response

The frequency response of the sound level meter (1/1 octave band) was taken by feeding constant acoustic input using a traceable multi-frequency acoustic calibrator (B&K 4226) at the diaphragm of the microphone of the sound level meter. The relative response of the sound level meter w.r.t. **1000 Hz** was as given below:

Frequency (Hz)	Relative Response w.r.t 1000 Hz (A-Weighting)
31.5	-39.0
63	-26.1
125	-16.0
250	-8.7
500	-3.2
1000	0
2000	1.2
4000	0.1
8000	-1.1

The evaluated expanded uncertainty in calibration is **± 1.0 dB** in frequency range **31.5 Hz to 8 kHz,** which is at a coverage factor ***k*=2**, and which corresponds to a coverage probability of approximately **95%** for a normal distribution.

8. Date of Calibration : 05. 10. 2023
9. Remarks : Nil

अंशांकनकर्ता:
Calibrated by : (DR. CHITRAGAUTAM)

जाँचकर्ता:
Checked by : (DR. NAVEEN GARG)

जारीकर्ता:
Issued by :

प्रभारी वैज्ञानिक:
Scientist-in-charge : (DR. NAVEEN GARG)

सी एस आई आर – राष्ट्रीय भौतिक प्रयोगशाला
CSIR-NATIONAL PHYSICAL LABORATORY
(विज्ञान तथा औद्योगिक अनुसंधान परिषद)
(Council of Scientific and Industrial Research)
राष्ट्रीय मापिकी संस्थान (एनएमआई), सदस्य बीआईपीएम एवं हस्ताक्षरकर्ता सीआईपीएम – एमआरए)
(National Metrology Institute (NMI), Member BIPM and Signatory CIPM - MRA)
डॉ. के. एस. कृष्णन् मार्ग, नई दिल्ली–110012, भारत
Dr. K. S. Krishnan Marg, New Delhi-110012, INDIA
दूरभाष/Phone : 91-11- 4560 8441, 8589, 8610, 9447, फैक्स/ Fax : 91-11-4560 8448
ई–मेल E-mail : cfct@nplindia.org, वेबसाइट Website : www.nplindia.org

अंशांकन प्रमाण पत्र
CALIBRATION CERTIFICATE
SOUND CALIBRATOR

प्रमाण पत्र संख्या/ Certificate No.
23090873/D1.07/C-128

दिनांक Date	अगले अंशांकन हेतु अनुशंसित तिथि Recommended date for the next calibration	पृष्ठ/ Page	पृष्ठों की संख्या / No. of Pages
16-10-2023	16-10-2025	1	1

1. Calibrated for : M/s TSI Instruments India Private Limited
Office No- 1203, 12th Floor, Eros Corporate park,
IMT Manesar, Gurugram,
Haryana – 122 050
Customer Reference: Nil dated 28/09/2023

2. Description and Identification of Item : **Casella Sound Calibrator Type: CEL-120/1**
S. No. 5007834.

3. Environmental Conditions : Room Temperature : (23.0 ± 5.0) °C
Relative Humidity : (50.0 ± 15.0) % RH
Atmospheric Pressure : 98.5 kPa

4. Standard used and Associated Uncertainty : Standard Condenser Microphone, B&K 4180 (LS2P)
S. No. 2702577, ± **0.10 dB**

5. Traceability of Standards used : The standard(s) used for calibration is (are) traceable to the National Standard, which realize the units of quantities according to the International System of Units (SI).

6. Principle/ Methodology of Calibration & Calibration Procedure No. : Comparison with Reference Standard,
Sub-Div. # 1.07/Doc. 3/CP # 04

7. Results

As requested by the party, the sound calibrator was calibrated for the following parameters under existing laboratory conditions.The generated **acoustic output** of the sound calibrator was found to be **94.0 dB and 114.0 dB at 1.000 kHz** corrected to standard atmospheric pressure of **101.3 kPa** and temperature of 23°C.

The evaluated expanded uncertainty in calibration is ± **0.25 dB** which is at a coverage factor **k=2** and which corresponds to coverage probability of approximately **95%** for a normal distribution.

8. Date of Calibration : 05. 10. 2023
9. Remarks : Nil

अंशांकनकर्ता
Calibrated by : (DR. CHITRA GAUTAM)

जाँचकर्ता
Checked by : Naveen Garg (DR. NAVEEN GARG)

जारीकर्ता
Issued by :

प्रभारी वैज्ञानिक
Scientist-in-charge : Naveen Garg (DR. NAVEEN GARG)

DEFENCE RESEARCH & DEVELOPMENT ORGANISATION

UTILIZATION CERTIFICATE

FOR THE FINANCIAL YEAR: 2023-2024 (From-10.01.2024 to 31.03.2024)

1	Title of the Project/Scheme	CARS with the title "Reduction of the sound level during the locking and unlocking operations of small-calibre guns"
2	Name of the Institution	Tezpur University
3	Principal Investigator	Paragmoni Kalita
4	DRDO Letter No. and Date of Sanctioning the Project Date of Start of the Project	DRDO Letter No. DRL/LS/Buildup/CARS/2023/15 Date: 13.10.2023 Date of start of the project: 10.01.2024
5	Head of Account as given in the Original Sanction Letter	Major Head-2080 Minor Head - 110
6	Amount brought forward from the previous financial year quoting DRDO Letter No. & Date in which the Authority to carry forward the said amount was given	Amount: Nil DRDO Letter No. and Date: Not Applicable
7	Amount received During the Financial Year (Please give No. and Date of DRDO Sanction Letter for the amount)	Rs. 8,10,000.00/-
8	Amount of interest accrued, if any, from the grants	Rs. 4072.00/-
9	Total amount that was available for Expenditure (Excluding Commitments) During the Financial Year (Sl. No. 6+7+8)	Rs. 8,14,072.00/-
10	Actual Expenditure (Excluding Commitments) incurred During the Financial Year (upto 31.03.2025)	Rs. 82,930.00/-
11	Balance amount available at the end of the Financial Year	Rs. 7,31,142.00/-
12	Unspent balance refunded, if any (Please give Details of Cheque No. etc.)	Nil
13	Amount allowed to be carried forward to the next Financial Year	Rs. 7,31,142.00/-

Kalita

UTILIZATION CERTIFICATE

FY 2023-2024 (From-10.01.2024 to 31.03.2024)

1. Certified that sum of ₹ 9,95,000.00/- was sanctioned as grants-in-aid during the year 2023-2024 in favour of Tezpur University (Instt.) vide DRDO letter No./ DRL/LS/Buildup/CARS/2023/15 dated 13.10.2023. A sum of ₹ 8,10,000.00/- *released* vide Letter No. DRL/LS/Buildup/CARS/2023/15 dated 13.10.2023 an amount of ₹4072.00/. accrued as interest (if any) during the year and ₹ Nil on account of unspent balance of the previous year, a sum of ₹ 82,930.00/-. has been utilized for the purposes for which it was sanctioned and the balance of ₹ Rs. 7,31,142.00/-. remaining unutilized at the end of the year will be ~~refunded~~/adjusted toward the grants-in-aid payable during the next year i.e., 2024-2025.

Principal Investigator	Accounts/Finance Officer 21/1/26 Finance Officer (I/c) Tezpur University	Administrative Authority (with official seal) 20/12/25 Registrar Tezpur University

2. Certified that I have satisfied myself that the conditions on which the grants-in-aid was sanctioned have been fulfilled/are being fulfilled and that I have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Signature of Audit Authority
of Grantee Institution

AUDITED PROVISIONAL STATEMENT OF EXPENDITURE ACCOUNTS

FOR THE FINANCIAL YEAR 2023-2024 (10.01.2024 to 31.03.2024)

DEFENCE RESEARCH AND DEVELOPMENT ORGANISATION

a) Title of the Project: Reduction of the sound level during the locking and unlocking operations of small-calibre guns

b) Sanctioned Letter No. & Date: DRL/LS/Buildup/CARS/2023/15, Date: 13.10.2023

c) Principal Investigator: Paragmoni Kalita

d) Date of Start of the Project: 10.01.2024

e) Total Sanctioned Cost of the Project: In Rs. 8,10,000.00.

f) Grant received (Rs. 8,10,000.00) in **I yr.** Rs. 8,10,000.00 **II yr.** .... **III yr.** ....

g) Total Grants received so far: ₹ Rs. 8,10,000.00 (Rupees eight lakhs and ten thousand)

S. No.	Sanctioned Heads	Funds Sanctioned for the year **Rs.**	Funds Released **Rs.**	Carried forward from Previous year **Rs.**	Funds available (iv+v) **Rs.**	Expenditure incurred during the FY **Rs.**	Balance (vi-vii) **Rs.**	Commitments **Rs.**	Total expenditure (vii+ix) **Rs.**
i	ii	iii	iv	v	vi	vii	viii	ix	x
a)	Staff	1,50,000.00	1,50,000.00	0.00	1,50,000.00	0.00	1,50,000.00	0.00	0.00
b)	Equipment	3,80,000.00	3,80,000.00	0.00	3,80,000.00	0.00	3,80,000.00	0.00	0.00
c)	Operation & Maint.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
d)	Expendables	70,000.00	70,000.00	0.00	70,000.00	0.00	70,000.00	0.00	0.00
e)	Travel	30,000.00	30,000.00	0.00	30,000.00	0.00	30,000.00	0.00	0.00
f)	Contingencies	35,000.00	35,000.00	0.00	35,000.00	1,680.00	33,320.00	0.00	1,680.00
g)	Research Consultant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
h)	Procured Service	15,000.00	15,000.00	0.00	15,000.00	0.00	15,000.00	0.00	0.00
	Institutional over head	1,30,000.00	1,30,000.00	0.00	1,30,000.00	81,250.00	48,750.00	0.00	81,250.00
	Interest earned, if any	0.00	4072.00		4072.00		4072.00		
	TOTAL	8,10,000.00	8,14,072.00	0.00	8,14,072	82,930.00	7,31,142.00	0.00	82,930.00

Kalita 23.12.2025

Name and Signature of Principal Investigator

Date: 23.12.2025

Name and Signature of Accounts Officer

Date: 20/12/25

Finance Officer (i/c)
Tezpur University

Signature of Administrative

Date: 20/12/25

Registrar
Tezpur University

DEFENCE RESEARCH & DEVELOPMENT ORGANISATION

UTILIZATION CERTIFICATE

FOR THE FINANCIAL YEAR: 2024-2025 (From-01.04.2024 to 31.03.2025)

1	Title of the Project/Scheme	CARS with the title "Reduction of the sound level during the locking and unlocking operations of small-calibre guns"
2	Name of the Institution	Tezpur University
3	Principal Investigator	Paragmoni Kalita
4	DRDO Letter No. and Date of Sanctioning the Project Date of Start of the Project	DRDO Letter No. DRL/LS/Buildup/CARS/2023/15 Date: 13.10.2023 Date of start of the project: 10.01.2024
5	Head of Account as given in the Original Sanction Letter	Major Head-2080 Minor Head - 110
6	Amount brought forward from the previous financial year quoting DRDO Letter No. & Date in which the Authority to carry forward the said amount was given	Amount: Rs. 7,31,142.00/- DRDO Letter No. DRL/LS/Buildup/CARS/2023/15 Date: 13.10.2023
7	Amount received During the Financial Year (Please give No. and Date of DRDO Sanction Letter for the amount)	Rs. 0.00/-
8	Amount of interest accrued, if any, from the grants	Rs. 5490.00/-
9	Total amount that was available for Expenditure (Excluding Commitments) During the Financial Year (Sl. No. 6+7+8)	Rs. 7,36,632.00/-
10	Actual Expenditure (Excluding Commitments) incurred During the Financial Year (upto 31.03.2025)	Rs. 5,11,558.00/-
11	Balance amount available at the end of the Financial Year	Rs. 2,25,074.00/-
12	Unspent balance refunded, if any (Please give Details of Cheque No. etc.)	Nil
13	Amount allowed to be carried forward to the next Financial Year	Rs. 2,25,074.00/-

Kalita

UTILIZATION CERTIFICATE

FY 2024-2025 (From – 01.04.2024 to 31.03.2025)

1. Certified that sum of ₹ 9,95,000.00/- was sanctioned as grants-in-aid during the year 2024-2025 in favour of Tezpur University (Instt.) vide DRDO letter No./ DRL/LS/Buildup/CARS/2023/15 dated 13.10.2023. A sum of ₹ 8,10,000.00/- *released* vide Letter No. DRL/LS/Buildup/CARS/2023/15 dated 13.10.2023 an amount of ₹ 5490.00/- accrued as interest (if any) during the year and ₹ 7,31,142.00/- on account of unspent balance of the previous year, a sum of ₹ 5,11,558.00/- has been utilized for the purposes for which it was sanctioned and the balance of ₹ 2,25,074.00/- remaining unutilized at the end of the year will be refunded/adjusted toward the grants-in-aid payable during the next year i.e. 2025-2026.

Principal Investigator	Accounts/Finance Officer Finance Officer (I/C) Tezpur University	Administrative Authority (with official seal) 30/12/25 Registrar Tezpur University

2. Certified that I have satisfied myself that the conditions on which the grants-in-aid was sanctioned have been fulfilled/are being fulfilled and that I have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Signature of Audit Authority
of Grantee Institution

AUDITED PROVISIONAL STATEMENT OF EXPENDITURE ACCOUNTS

FOR THE FINANCIAL YEAR 2024-2025 (01.04.2024 to 31.03.2025)

a) Title of the Project: Reduction of the sound level during the locking and unlocking operations of small-calibre guns

b) Sanctioned Letter No. & Date: DRL/LS/Buildup/CARS/2023/15, Amended on Date: 06.01.2025

c) Principal Investigator: Paragmoni Kalita

d) Date of Start of the Project: 10.01.2024

e) Total Sanctioned Cost of the Project: In Rs. 8,10,000.00.

f) Grant received (Rs. 8,10,000.00) in **I yr.** Rs. 8,10,000.00 **II yr.** .... **III yr.** ....

g) Total Grants received so far: ₹ Rs. 8,10,000.00 (Rupees eight lakhs and ten thousand)

S. No.	Sanctioned Heads	Funds Sanctioned for the year Rs.	Funds Released Rs.	Carried forward from Previous year Rs.	Funds available (iv+v) Rs.	Expenditure incurred during the FY Rs.	Balance (vi-vii) Rs.	Commitments Rs.	Total expenditure (vii+ix) Rs.
i	ii	iii	iv	v	vi	vii	viii	ix	x
a)	Staff	1,50,000.00	0.00	1,50,000.00	1,50,000.00	1,38,658.00	11,342.00	0.00	1,38,658.00
b)	Equipment	3,80,000.00	0.00	3,80,000.00	3,80,000.00	3,68,900.00	11,100.00	0.00	3,68,900.00
c)	Operation & Maint.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
d)	Expendables	70,000.00	0.00	70,000.00	70,000.00	0.00	70,000.00	0.00	0.00
e)	Travel	30,000.00	0.00	30,000.00	30,000.00	4,000.00	26,000.00	0.00	4,000.00
f)	Contingencies	35,000.00	0.00	33,320.00	33,320.00	0.00	33,320.00	0.00	0.00
g)	Research Consultant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
h)	Procured Service	15,000.00	0.00	15,000.00	15,000.00	0.00	15,000.00	0.00	0.00
	Institutional over head	1,30,000.00	0.00	48,750.00	48,750.00	0.00	48,750.00	0.00	0.00
	Interest earned, if any		5490.00	4072.00	9,562.00		9,562.00		
	TOTAL	8,10,000.00	5490.00	7,31,142.00	7,36,632.00	5,11,558.00	2,25,074.00	0.00	5,11,558.00

Kalita 23.12.2025

Name and Signature of Principal Investigator

Date: 23.12.2025

Name and Signature of Accounts Officer

Date:

Finance Officer (i/c)
Tezpur University

Signature of Administrative

Date: 30/12/25

Registrar
Tezpur University

DEFENCE RESEARCH AND DEVELOPMENT ORGANISATION

DEFENCE RESEARCH & DEVELOPMENT ORGANISATION

UTILIZATION CERTIFICATE

FOR THE FINANCIAL YEAR: 2025-2026 (From-01.04.2025 to 10.07.2025)

1	Title of the Project/Scheme	CARS with the title "Reduction of the sound level during the locking and unlocking operations of small-calibre guns"
2	Name of the Institution	Tezpur University
3	Principal Investigator	Paragmoni Kalita
4	DRDO Letter No. and Date of Sanctioning the Project Date of Start of the Project	DRDO Letter No. DRL/LS/Buildup/CARS/2023/15 Date: 13.10.2023 Date of start of the project: 10.01.2024
5	Head of Account as given in the Original Sanction Letter	Major Head-2080 Minor Head - 110
6	Amount brought forward from the previous financial year quoting DRDO Letter No. & Date in which the Authority to carry forward the said amount was given	Amount: Rs. 2,25,074.00/- DRDO Letter No. DRL/LS/Buildup/CARS/2023/15 Date: 13.10.2023, Amended on 06.01.2025
7	Amount received During the Financial Year (Please give No. and Date of DRDO Sanction Letter for the amount)	Rs. 0.00/-
8	Amount of interest accrued, if any, from the grants	Rs. 894.00/0
9	Total amount that was available for Expenditure (Excluding Commitments) During the Financial Year (Sl. No. 6+7+8)	Rs. 2,25,968.00/-
10	Actual Expenditure (Excluding Commitments) incurred During the Financial Year (upto 31.03.2025)	Rs. 95,886.00/-
11	Balance amount available at the end of the Financial Year	Rs. 1,30,082.00/-
12	Unspent balance refunded, if any (Please give Details of Cheque No. etc.)	Rs. 1,30,082.00/- DD No. 848806, dated 19.01.2026 In favour of Director DRL Tezpur
13	Amount allowed to be carried forward to the next Financial Year	Nil

Kalita

UTILIZATION CERTIFICATE

FY 2025-2026 (From – 01.04.2025 to 10.07.2025)

~~1.~~ Certified that sum of ₹ 8,10,000.00/- was sanctioned as grants-in-aid during the year 2025-2026 in favour of Tezpur University (Instt.) vide DRDO letter No./ DRL/LS/Buildup/CARS/2023/15 dated 06.01.2025 (second amendment). A sum of ₹8,10,000/- *released* vide Letter No. DRL/LS/Buildup/CARS/2023/15 dated 13.10.2023 an amount of ₹ 894.00 accrued as interest (if any) during the year and ₹ 2,25,074.00/- on account of unspent balance of the previous year, a sum of ₹ 95,886.00/- has been utilized for the purposes for which it was sanctioned and the balance of ₹ 1,30,082.00/-. remaining unutilized at the end of the year will be refunded/~~adjusted toward the grants-in-aid payable during the next year i.e.~~ ....

Principal Investigator	Accounts/Finance Officer Finance Officer (i/c) Tezpur University	Administrative Authority (with official seal) Registrar Tezpur University

2. Certified that I have satisfied myself that the conditions on which the grants-in-aid was sanctioned have been fulfilled/are being fulfilled and that I have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Signature of Audit Authority
of Grantee Institution

AUDITED PROVISIONAL STATEMENT OF EXPENDITURE ACCOUNTS

FOR THE FINANCIAL YEAR 2025-2026 (01.04.2025 to 10.07.2025)

a) Title of the Project: Reduction of the sound level during the locking and unlocking operations of small-calibre guns

b) Sanctioned Letter No. & Date: DRL/LS/Buildup/CARS/2023/15, Amended on Date: 06.01.2025

c) Principal Investigator: Paragmoni Kalita

d) Date of Start of the Project: 10.01.2024

e) Total Sanctioned Cost of the Project: In Rs. 8,10,000.00.

f) Grant received (Rs. 8,10,000.00) in **I yr.** Rs. 8,10,000.00 **II yr.** .... **III yr.** ....

g) Total Grants received so far: ₹ Rs. 8,10,000.00 (Rupees eight lakhs and ten thousand)

S. No.	Sanctioned Heads	Funds Sanctioned for the year **Rs.**	Funds Released **Rs.**	Carried forward from Previous year **Rs.**	Funds available (iv+v) **Rs.**	Expenditure incurred during the FY **Rs.**	Balance (vi-vii) **Rs.**	Commitments **Rs.**	Total expenditure (vii+ix) **Rs.**
i	ii	iii	iv	v	vi	vii	viii	ix	x
a)	Staff	1,50,000.00	0.00	11,342.00	11,342.00	0.00	11,342.00	0.00	0.00
b)	Equipment	3,80,000.00	0.00	11,100.00	11,100.00	0.00	11,100.00	0.00	0.00
c)	Operation & Maint.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
d)	Expendables	70,000.00	0.00	70,000.00	70,000.00	46,491.00	23,509.00	0.00	46,491.00
e)	Travel	30,000.00	0.00	26,000.00	26,000.00	0.00	26,000.00	0.00	0.00
f)	Contingencies	35,000.00	0.00	33,320.00	33,320.00	1,645.00	31,675.00	0.00	1,645.00
g)	Research Consultant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
h)	Procured Service	15,000.00	0.00	15,000.00	15,000.00	0.00	15,000.00	0.00	0.00
	Institutional over head	1,30,000.00	0.00	48,750.00	48,750.00	47,750.00	1,000.00	0.00	47,750.00
	Interest earned, if any		894.00	9,562.00	10,456.00		10,456.00		
	TOTAL	8,10,000.00	894.00	2,25,074.00	2,25,968.00	95,886.00	1,30,082.00	0.00	95,886.00

Kalita 23.12.2025

Name and Signature of Principal Investigator

Date: 23-12-2025

30/12/25

Name and Signature of Accounts Officer

Date:

Finance Officer (i/c)
Tezpur University

Signature of Administrative

Date: 30/12/25

Registrar
Tezpur University

DEFENCE RESEARCH AND DEVELOPMENT ORGANISATION