THE STUDY DESIGN OF NOISE CONTROL SILENCERS FOR BLEEDER ON RETORT

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ABSTRACT

Currently, in a lot of the canning food industries in Thailand, large retorts are used for the processing of canned food under steam pressure or for sterilization of food packaged in containers. These use steam bled from a Bleeder that makes a noise and affects nearby employee's hearing. This research aimed to design sound reducing equipment (Silencers) with 3 types, that are Silencer A, B and C. We designed them to have an outside cover pipe and an inside cylindrical pipe. Each silencer differed in its hole's sizes and the number of inside holes, silencer A has 30 off 4.75 millimeter diameter holes. Silencer B has 60 off 4.75 millimeter diameter holes. Silencer C has 9 off 8.76 millimeter diameter holes.

Firstly, we examined noise reduction from air pressure. Then we choose the most reductive silencer to test in the retort's steam bleeding. At 20 PSIG air pressure, we found a 90.5 dB noise level with the Bleeder installation and 80.3 dB with the silencer installation. That was a 10.3 dB reduction. So, we choose the best noise reducing silencer to test the Bleeder's steam noise reduction at 12 PSIG air pressure. From the testing undertaken during the bleeding installation the noise was 92.2 dB and 79.0 dB for the silenced installation. The result is we have significant 13.2 dB statistical reduction. (P-value <0.001)

KEY WORDS: SILENCER A/ SILENCER B/ SILENCER C/ BLEEDER/RETORT

66 pages

การออกแบบอุปกรณ์ลดเสียงจากการระบายไอน้ำของหม้อฆ่าเชื้อ

STUDY DESIGN OF NOISE CONTROL SILENCER FOR BLEEDER ON RETORT

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บทคัดย่อ

ปัจจุบันนี้อุตสาหกรรมอาหารกระป๋องในประเทศไทยจำนวนมากมีการใช้อุปกรณ์ภายใต้ความดันสูงหรือหม้อฆ่าเชื้อ (เครื่องรีทอร์ท) สำหรับฆ่าเชื้ออาหารที่บรรจุในภาชนะเรียบร้อยแล้ว ซึ่งในกระบวนการผลิตจะมีการระบายไอน้ำผ่านวาล์วระบายไอน้ำ (Bleeder) ก่อให้เกิดเสียงดัง ที่เป็นอันตรายต่อการได้ยินของพนักงานที่ทำงานในพื้นที่ใกล้กับรีทอร์ท การศึกษาวิจัยครั้งนี้จึงได้มุ่งเน้นเพื่อออกแบบอุปกรณ์ลดเสียง (Silencer) โดยออกแบบอุปกรณ์ลดเสียงเป็น 3 ชนิด คือ ไซเลนเซอร์ A, B และ C โดยได้ออกแบบไซเลนเซอร์ ให้มีท่อครอบด้านนอก และมีท่อภายในทรงกระบอก ซึ่งไซเลนเซอร์แต่ละชนิดแตกต่างกันที่ขนาดรูและจำนวนรูของท่อภายใน โดยไซเลนเซอร์ A เจาะรูขนาดเส้นผ่านศูนย์กลาง 4.75 มิลลิเมตร จำนวน 30 รู ไซเลนเซอร์ B เจาะรูขนาดเส้นผ่านศูนย์กลาง 4.75 มิลลิเมตร จำนวน 60 รูและไซเลนเซอร์ C เจาะรูขนาดเส้นผ่านศูนย์กลาง 8.76 มิลลิเมตร จำนวน 9 รู

โดยทำการทดสอบการลดเสียงจากความดันลมก่อนแล้วจึงเลือกไซเลนเซอร์ที่สามารถลดเสียงได้มากที่สุดไปทดสอบการลดเสียงจากการระบายไอน้ำของ Bleeder ของเครื่องรีทอร์ท จากการทดสอบตรวจวัดเสียงจากลมที่ความดันลม 20 PSIG พบว่ามีระดับเสียงดังเมื่อติดตั้ง Bleeder เท่ากับ 90.5 เดซิเบล และระดับเสียงเมื่อติดตั้ง Silencer เท่ากับ 80.3 เดซิเบล พบว่าระดับเสียงลดลง 10.3 เดซิเบล จึงนำไซเลนเซอร์ที่สามารถลดเสียงได้มากที่สุดไปทดสอบการลดเสียงจากการระบายไอน้ำของ Bleeder ของเครื่องรีทอร์ทที่ความดัน 12 PSIG จากการทดสอบตรวจวัดเสียงขณะติดตั้ง Bleeder มีระดับเสียงเท่ากับ 92.2 เดซิเบลและขณะติดตั้งไซเลนเซอร์แทน Bleeder มีระดับเสียง 79.0 เดซิเบล ผลการศึกษาพบว่าไซเลนเซอร์สามารถลดเสียงได้ 13.2 เดซิเบล อย่างมีนัยสำคัญทางสถิติ (P-value <0.001)

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CHAPTER I
INTRODUCTION

1.1 Background and Rationale

The over standard of sound level is a problem in food industry. Mostly sound came from production machine (conveyor, table's vibration, product transportation) and another transportation by employees. Most of hearing loosing was came from sounds touching around 1 – 5 years. From survey by Labor and Industry Department Washington USA since 1994 – 1999, They found more than 200 employee who work in food industry got payment for hearing loosing 10,000 us dollars person[(1)] in average. And from the study compensate for Hearing Loosing around the world year 2000 , they found that Hearing loosing from working 16% (More than 4 million person per day) [(2)] and from observation in USA year 1997-2003 they found employees in USA 12.2 Million persons (11.4%) had hearing problem that cause of private behavior. In this numbers , 3.3 million persons (24%) lost hearing from working[(3)] and in year 1997 – 2004 found that 22 million persons touched dangerous sound in their working place. In this numbers , more than 7 million persons (34 %) did not wear hearing protector.[(4)] They also get the research result that not only loudly sound affected to hearing but another affected ,too. Such as faster heartbeat , blood pressure , Aortic stenosis. For long term its affected to heart symptoms. Besides , it still affect to Hormone secretion, muscle stretching , emotional and mind. These symptoms still affect to all over effectiveness production .

Mostly sound affected dangerous cannot be treated. So, Over Standard Sound Protection is the only way that can reduce health damage. [(5)]

There are 3 ways for sound control as The noise source control , pathway and receiver who touch sound. For example [(6)] 1. control at noise source. Suitable machine maintenance , Silencer using for vent sound control , Machine covered and new lay out for machines. 2. control at pathway such as making wall that can protect

sound and install sound absorb material or covered and control at receiver. Such as working rotating and use hearing protector.

As above things , can found that mostly machine improvement or design were depend on the manufacturer. Using Hearing Protector should be considered for the least. It is because mostly of them did not wear Hearing Protector all the working time when they are in Loudly place , Maintenance , Improve or Places .It is ineffective for reducing .So , Sound Diagonal Material or Silencers Using between the genesis and employees should be considered because its control sound for genesis field . [2] That is the best way to protect.[7]

In the food and beverage industry, they have sound level that higher than 85 dB (A) and 90 dB (A) [8] that affected to environment such as steam flowing from safety valve of boiler that made more 20-30 dB (A) in 1 kilometer radiant.[9] And from the study case of Thailand Canned Food Factory , found 87.9 – 96.6 dB (A) [10] And employees who touched high level sound did not use hearing protector. [11] Currently , canned food industry have high pressure equipment or retort to retort canned food. They retort be steam heat or steam water mixed with high pressure air. When they finished, the vent will be opened and flow steam to atmosphere . We will explain about this vent in “come down” temperature phase during production cycle. It consist of “come up” temperature phase and “come down” temperature phase. The steam will flow into the air and pass to vent, bleeders. Its made very loud sound and dangerous to employees who working near retort.

Aforementioned, It made employees who work in canned food industry’s retort area touched the over standard sound. This is the urgently requirement of Occupational Health and Safety (OSHA). So, they limit sound level in Factory environment and specify reducer equipment installation for loud area that affected to employees. Basically, Muffler silencers installation for retorts sound. During making it can get some trouble such as erosion that came from steam and steam condensation . These working can interrupt muffler and made production heat reduced . Then its damage production process .

Another problem is the muffler must be cannot interrupt steam flowing. It is because more pressure and damage production process. So, employees should have indicators that can help them can see steam flowing pass to bleeders and vent all the

time. This is for suitable production process control. So, muffler must be not covered steam flowing process. [12]

Silencers is the sound energy equipment that has air or gas flowing from one place to another place. For example, engine air system that flow into atmosphere and made noise. It has to be controlled but air and gas still can passes. Or in case the fan in air-condition that make noise, it has to be controlled with controller equipment called “Silencers” or Silencer in USA Style. The example of the sound genesis that use silencers is “the pipe in air flow system” (HVAC) “engine air flow pipe” “ Turbine gas and compressor” “Rotary Pump”. The ability of sound reduce came from “impedance” value changing and absorb sound equipment. Silencers for sound control has 2 types that separated by working as Dissipative Silencer and Reactive Silencer. So , these two types are interesting way for steam retorts sound reducing.[6]

Canned Food Factory is the one of 43 working place that related with Public Health Enactment 1992. In Thailand, we have 423 canned food factories.(Industry Department 2012) [13] The big canned food factories use the retorts (Retort) in production process and they produce per day for long period. The researcher found that sound of retort in two Tuna Factories Samutsakorn Province can be 91.0 – 95.6 dB(A) . Sound level at retort area in Coconut Milk Factory , Samutsongkram Province can be 90 dB(A) and at retort area in Corn Factory ,Chiangmai can be 92 dB(A) . The retort sound level of food factory in Kuwait can be 90 dB(A) ,[11] that over sound standard NIOSH , 1998. It made employees who working around that area have risk to lost their hearing.

From the above, under this study objective. Researcher would like to design silencer that can reduce sound level from steam flowing by retort and hope that this study can get the silencer that not easy for erosion , not expensive , easy to install , refrain and can be more developed for sound reducing in canned food factories later.

1.2 Objective

1.2.1 To design and fabrication silencers up to reduce noise from air pressure and steam flowing.

1.2.2 To compare sound level of air pressure and steam flowing before and after silencers installation.

1.2.3 To find quantity of bleeders total area and air pressure flowing vent that can reduce sound to be not over 85 dB.

1.2.4 Silencer that actually works differently from bleeder.

1.3 Hypothesis

1.3.1 The silencers from design can reduce noise of air pressure 10 dB at least .

1.3.2 The total area of the air holes is greater than the noise.

1.3.3 The silencers from design can reduce noise of steam flowing 10 dB at least.

1.4 Variables

1.4.1 Independent Variables

1) Silencers A Type
2) Silencers B Type
3) Silencers C Type

1.4.2 Flexible Variables

1) Sound Level

1.4.3 Control Variables

1) Pressure
2) Temperature

1.5 Scope of study

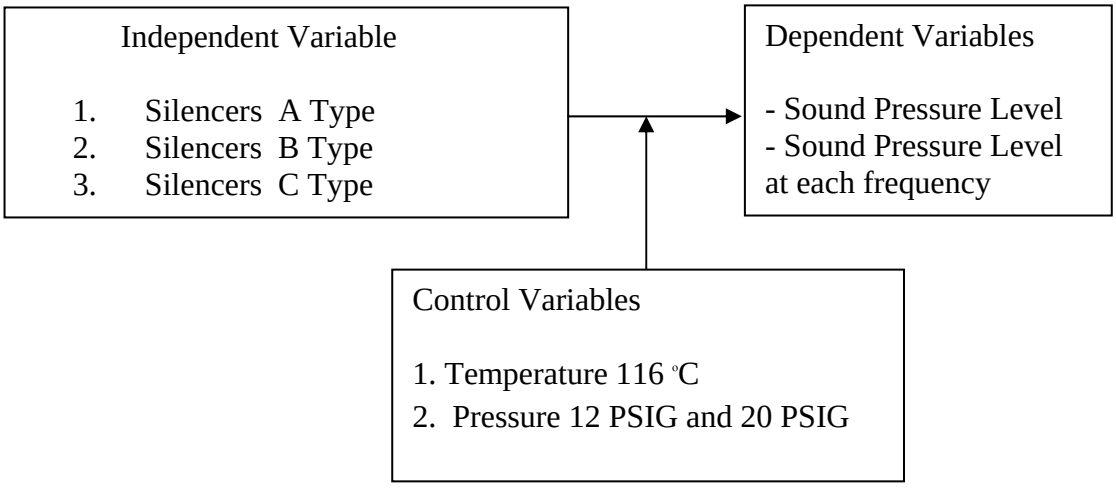
In this study , we have limited item that is for the experimental silencers effectiveness, we must try reduce sound by air pressure passing first. Then we choose silencers that can reduce sound more to try with steam later.

1.6 Advantages obtained from the research

1.6.1 To reduce sound at genesis that came from flowing by silencers installation.

1.6.2 To protect and reduce hearing loosing of related employees.

1.7 Research boundaries



1.8 Definitions

Silencer type A : The cylindrical vent that has diameter 6.35 mm, long 38.1 mm, thick 13.46 mm. Punched hole that had diameter 4.75 mm for 30 holes and wrap with

cylindrical vent that has diameter 54.66 mm, long 76.2 mm and thick 2.60 mm**.**

Silencer type B : The cylindrical vent that has diameter 6.35 mm. long 38.1 mm., thick 13.46 mm. Punched hole that had diameter 4.75 mm for 60 holes and wrap with cylindrical vent that has diameter 54.66 mm., long 76.2 mm and thick 2.60 mm**.**

Silencer type C : The cylindrical vent that has diameter 6.35 mm. long 38.1 mm., thick 13.46 mm. Punched hole that had diameter 8.76 mm for 9 holes and wrap with cylindrical vent that has diameter 54.66 mm., long 76.2 mm and thick 2.60 mm**.**

Silencers : The equipment for sound reducing of air, steam flowing from one place to another place.

Retort : The equipment that work under high pressure use for retort by steam heat or steam water with high pressure air. (Overriding air pressure)

Bleeder : The kind of tube that use foe water drain from retort boiler.

CHAPTER II
LITERATURE REVIEW

2.1 Noise Source from retorts [14]

Currently, in the canning food industry, large retort are used processing of canned food under steam pressure. During an entire process cycle including come-up and come-down periods steam escaping to the ambient surrounds through the bleeder creates a sound so loud (high velocity gas) as to be a potential hazard to the hearing of human operator in the vicinity of the retort. that this study is for understanding one noise that is noise form steam flowing by bleeders passing of retort as the Figure 2.1

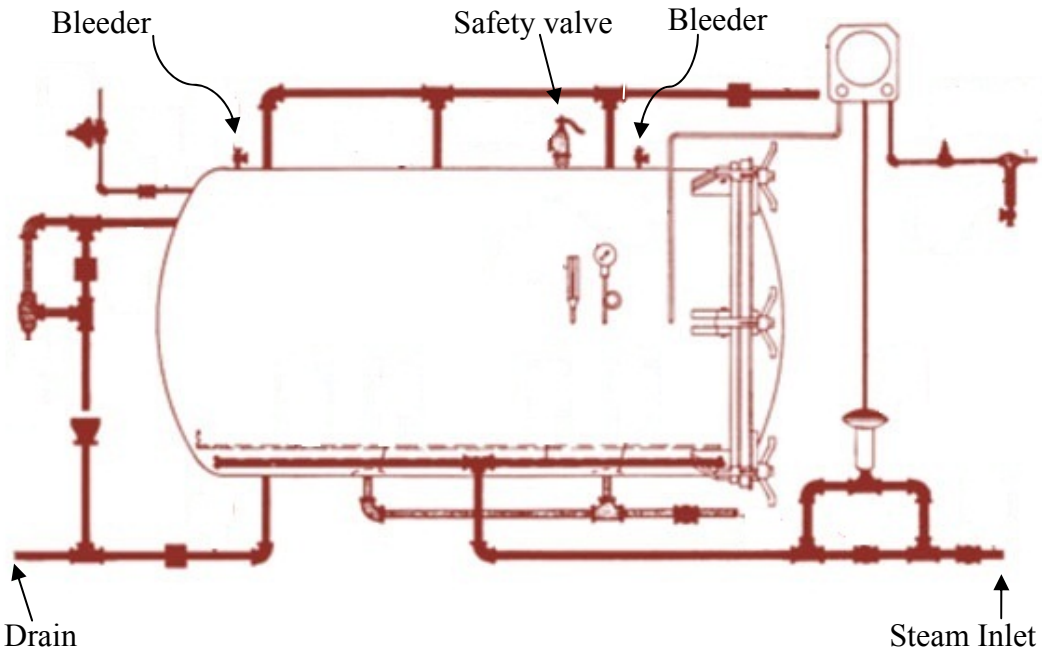


Figure 2.1 : Schematic diagram of horizontal retort

Retort's working is start from step 1 Inlet water valve opened and water come into boiler that reach the setting level. It will not over steam vent level. Or the other choice is we can increase water temperature to our goal temperature.

Step 2 Steam Valve and wind pump opened together that made the steam mixed with eject water from besides and upside to spread the heat inside boiler fastly until the temperature can increase to retort. At the same time , Air valve will opened automatically to control pressure inside boiler. That can protect production damage.

Step 3 Steam Valve and wind pump opened together that made the steam mixed with eject water from besides and upside to spread the heat inside boiler fastly until the temperature can increase to retort. At the same time , Air valve will opened automatically to control pressure inside boiler. That can protect production damage.

Step 4 When retort process finished , Steam valve will be closed and cold water valve will be opened. Cold water come into The Heat Changing Machine again and again until the temperature can be reduced and reach the goal temperature. At that time, Draining Valve water will opened to keep water inside boiler. The pressure inside boiler still was controlled to protect production damage.

Step 5 When the temperature was reduced to the goal level , water pump will stopped and pressure flowing valve opened to reduce pressure inside boiler equal as atmosphere pressure. After that, drain water valve will opened to drain water, then the gate system will opened automatically.

The position that has noise during high steam discharge to atmosphere is bleeder. During production process, we will open bleeder since the start of air punching phase. It pass retort come up temperature to retort process time and through the cool down time. The objective of bleeding opening is to flow the steam inside the retort. Then the steam will pass the heat changing process by float out from the bleeder. It made flowing all the time. If we don't open bleeder, the steam will condensate inside boiler, then it can be a heat covered. The heat exchange can low down and get more high pressure in retort because there was not bleeder which very dangerous. Normally, we punch ¼ inch. We will install bleeders as the specific requirement. How many. At least 1 point at front cap, 1 point at thermometer, 1 point on the back of retort . For vertical retort, we install 3 points. If it is horizontal retort, we add more 1 point in every 8 feet length of retort's length. Such as the retort long 16 feet, we add more 4 points are top , middle ,bottom and at the thermometer . We study the retort that have bleeders as the Figure 2.1.

2.2 Free jet sound Mechanism[15]

High velocity gas that act with atmosphere around made mixing between stress, shear and turbulent heavily. This mixing made noise and sound energy will depends speed ad 8 times by equation of Light hill.

$$W_A \propto \frac{P_j S_j U^8_j}{C^5} \quad \text{..... Equation 2.1}$$

With W is sound energy , W

Pj is Air density level , kgm^{-3}

Sj is extremely expansion area (size) , m

C is sound speed , ms^{-1}

U is Flowing rate , ms^{-1}

Small vent has more high frequency and big vent has low frequency sound . Highest frequency as equation.

$$f_p = \frac{0.2U_j}{D_j} \quad \text{..... Equation 2.2}$$

With f_p is Highest frequency , Hertz

D_j is Diameter of highest expanding air , m

Gas and Steam flowing are specified by flow pressure gas passing to control valve , pressure flowing valve , burst disk or other gap that flow to atmosphere . Continuously Flowing and working phase by phase are together in this definition. This is leaving opened (Blow down) that flow stable gas quantity.

This using process was in the industry but still has disturbance noise. So , Noise reducing is the thing we can do by use Vent Silencers that can connected with suitable control valve.

2.3 Noise from fluid pipe [16]

Production system and Fluid passing are mainly genesis of Industry noise. The ingredient inside system that make noise are control valve, high speed steam opened – closed expanding , compressor and pump . The mainly noise genesis of fluid system came from control valve that has noise from turbulent flowing steam. Noise from control valve has 3 genesis that are

2.3.1 Mechanical Vibration

Mechanical noise has the cause from Resonance at valve's part and turbulent flow that pass through the valve. Turbulent Flow attach the inside parts of valve till induct vibration around another parts.

2.3.2 Aerodynamic noise

Aerodynamic noise has cause from mechanical energy changing of flowing rates to sound energy. Such as restriction valve flow passing. The rate of this changing was called "Acoustical Efficiency" and it relate with valve pressure ratio and the noise that has turbulent or noise that made up without reaction between fluid and vibration boundary or another outside energy.

Aerodynamic noise is the result of Reynolds Stress or Shear that came from speed reducing, expanding or crashing. Mainly area of noise in control valve is the immediately lift up area of vent's outing way.

2.3.3 Hydrodynamic noise

Its happen by liquid flowing that pass valve or vent system. It has 3 kinds of genesis are Liquid Flowing Noise, Cavitations Noise and Flashing Noise. The Cavitations Noise is the important thing because the sound can shown that we already had some damage inside valve and vent.

The genesis of cavity noise in style of Hydrodynamic came from Vapor bubble explosion. Its cause from outlet valve flowing has stable pressure more than vapor bubble pressure and some point inside valve has stable specific pressure (Does not matter that came from high speed and / or turbulent hardly) that the valve less than or equal liquid vapor pressure.

2.4 Basically principle to control noise[17]

For noise problem solving, It is convenience thing for seeing in genesis system , passing way and noise receiver. The system can be shown below.

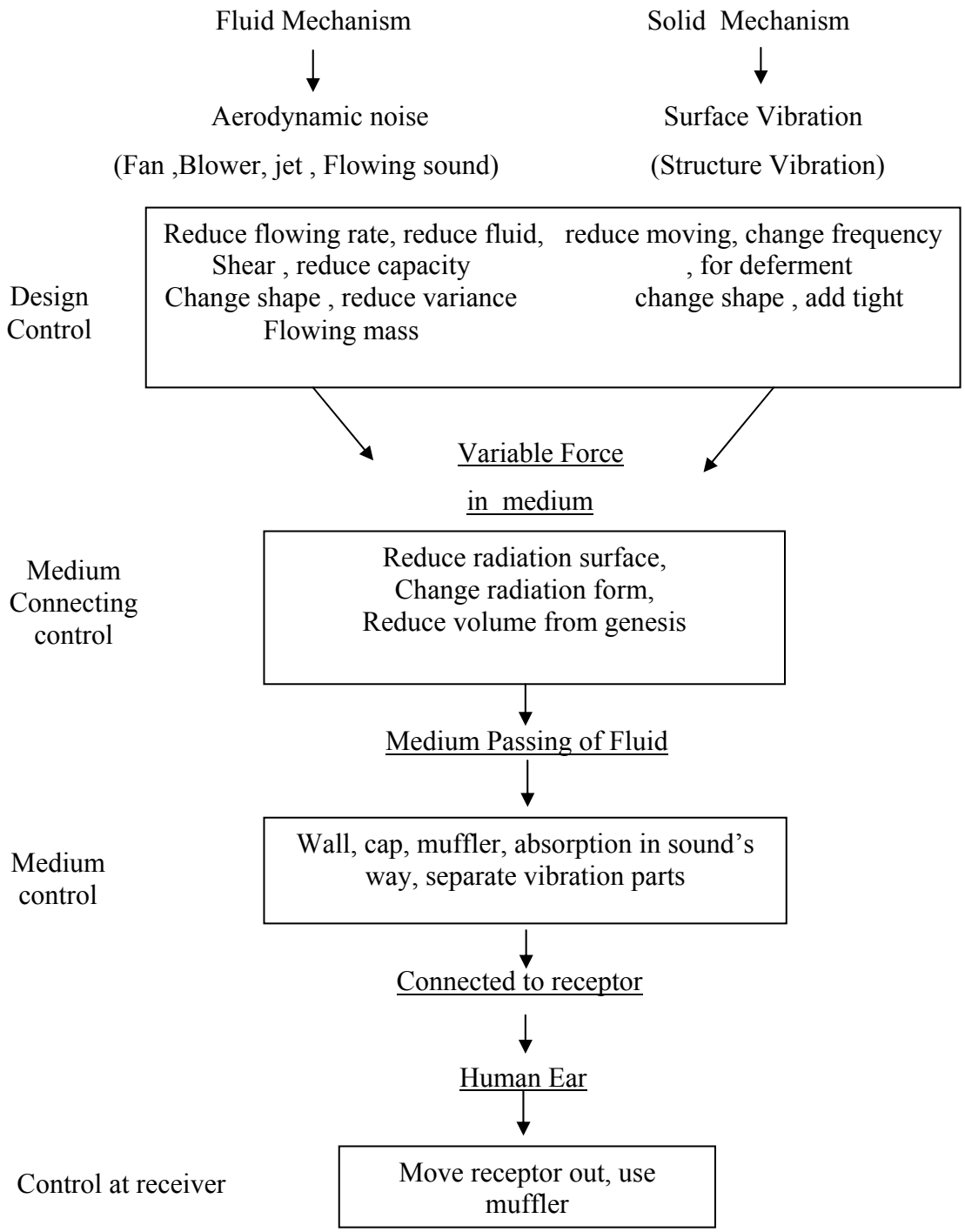


Figure 2.2 Noise control conclusion

2.5 Gas and Steam flowing Noise Control Approach [5]

2.5.1 Jet body that has low frequency can reduce sound level by change to be high frequency sound

If the outlet jet's diameter was big , we can get the low frequency sound but if diameter was small , we get high frequency sound. The vent that has low frequency sound can be changed to high frequency sound by using many small vent instead only one outlet vent. The result is high frequency sound that easy to control as Figure 2.3

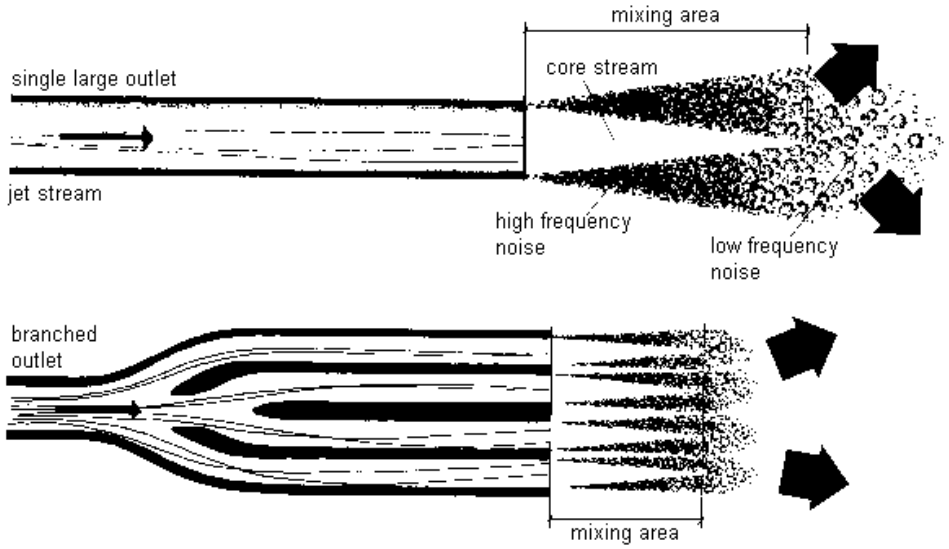


Figure 2.3 Jet body that has low frequency can reduce sound level by change to be high frequency sound

For Example , The safety valve of boiler will flow steam many times per day. The sound is low frequency and very noise. **Control** : Funnel porous. This porous will make many small jet and high frequency sound that can be absorbed by absorb material that putting on downstream.
as Figure 2.4

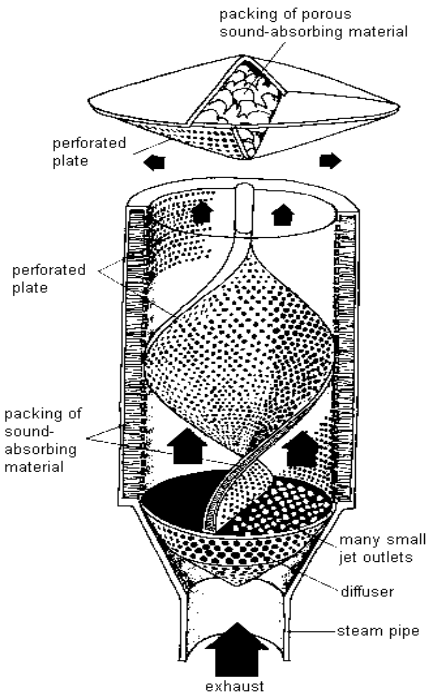


Figure 2.4 Reducing sound equipment from boiler safety valve

2.5.2 Rapid pressure changes produce more noise

If the Fluid pressure in system can happens from capacity fastly changing, the escape way from a sound so loud can be done. By adding air capacity as Figure 2.5

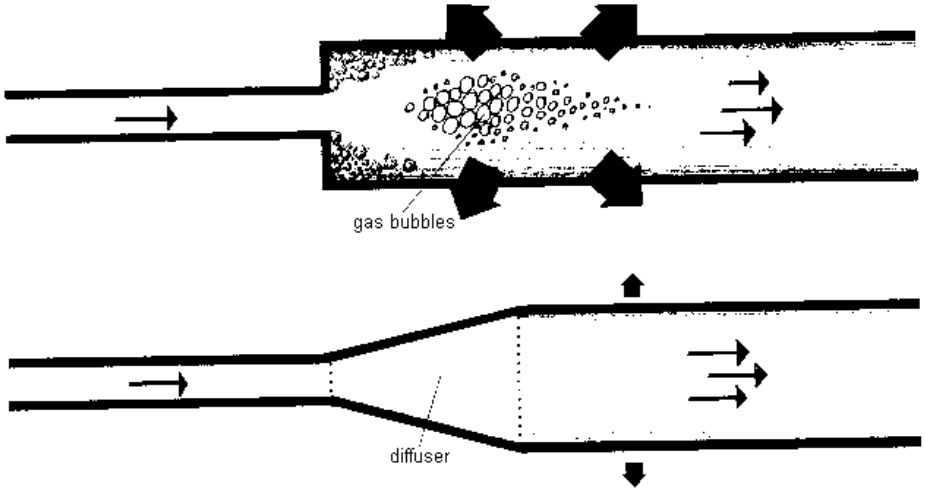


Figure 2.5 Fastly changing pressure can made more loud sound

2.5.3 Vent's size changing can reduce expanding sound.

With way changing , some energy will reflect. So , we can apply this way to use with vent by bent it , separate it and change capacity , drawing or change vent's material as Figure 2.6

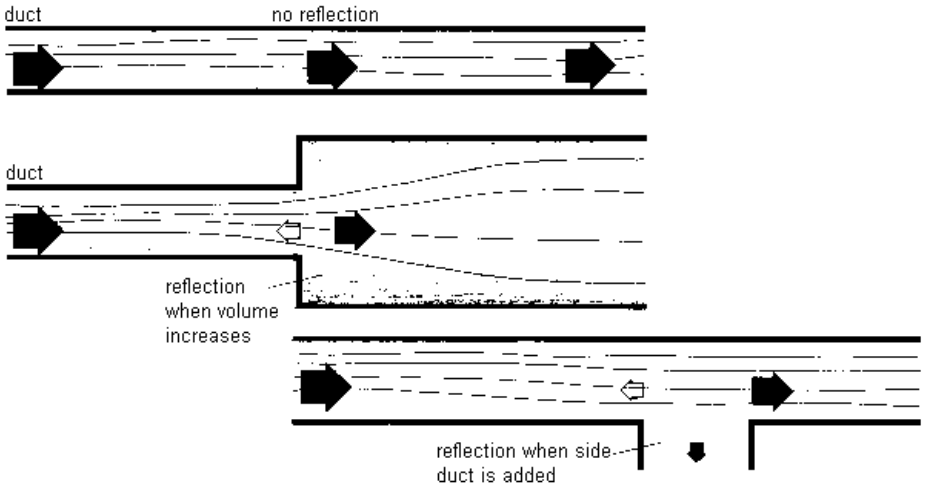


Figure 2.6 Vent's size changing can reduce expanding sound

2.5.4 Gap expanding can reduce low frequency sound.

Inside vent that expanded or has gap , the pressure of low frequency will increase. For this gap , If it more big it can reduce more low frequency as Figure 2.7

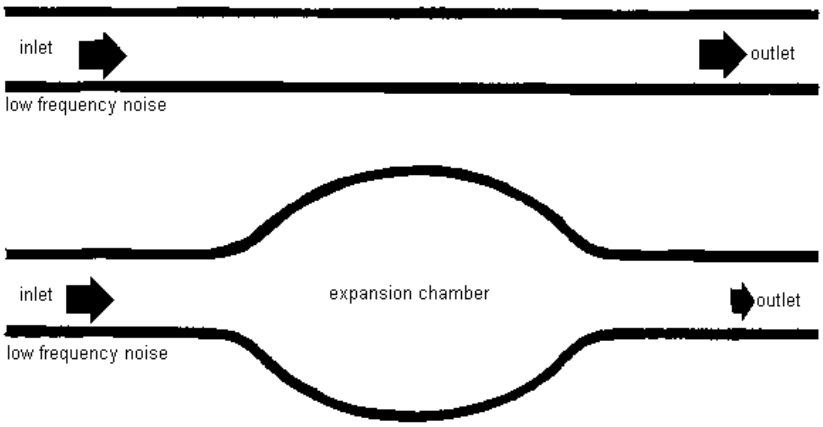


Figure 2.7 Gap expanding can reduce low frequency sound.

2.5.5 Sound Reducing Machine can have good result in narrow frequency phase.

If the sound appear in limited phase , Reducing machine reflection type can get the good result. For low frequency phase normally. If the sound has wide frequency , it has to use many gaps to reflect. So , the vent that punched small can be helped to reduce sound by reflection as Figure 2.8

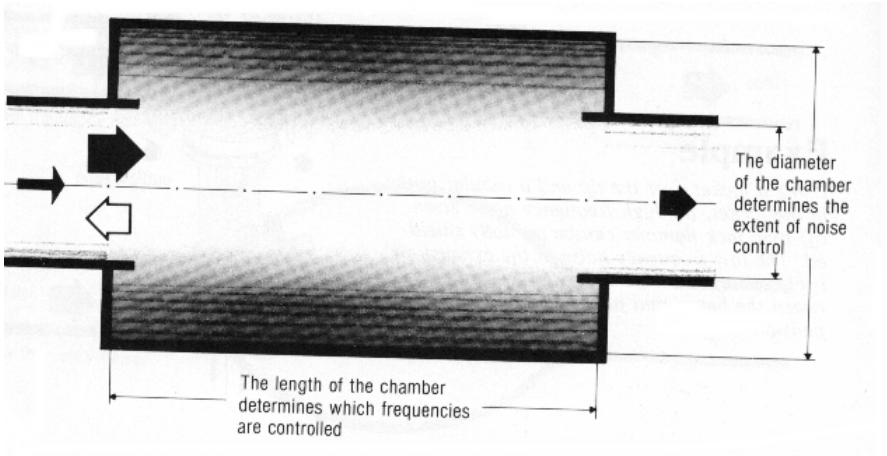


Figure 2.8 Sound reducing machine can have good result in narrow frequency phase.

2.6 Silencer [6]

For working , many activities that have gas or air flowing from one place to another place. In case of air system in engine flow into atmosphere that cause of loudly sound. We have to control it but the gas or air still can pass. Or in case of air-conditioner's fan that made loudly sound , we have to use sound control equipment that called silencers or in USA called silencer. For using silencers , we use in airborne noise case that happens from the genesis ,then pass to vent. Or airborne that happens from air mass turbulent that pass along the vent.

For the example of genesis that use silencers , such as Air system's vent (HVAC) ,Turbine Gas and compressor , Rotary Pump. We have 2 kinds of silencer that separate by working style are

2.6.1 Dissipative Silencer

This silencer can work by decay the sound energy that became to heat and install sound absorb material with. It can cover area of sound more than Reactive Silencer. Example , Silencer that install in Air Flow System has many gaps to separate or expand sound that crash to absorb material.(Backside of plaque) This silencer can reduce sound in many phase of frequency quite good. When we install sound absorb material inside air flow , we can calculate the amount of sound level reduce per vent 1 feet length from this สูตร

$$\Delta L = 12.6\, P\alpha^{1.4} / S$$

When ΔL = Sound level changing , dB/Feet

P = Periphery of vent that has absorb material , Inch

S = The cross section of vent surface , $inch^2$

α = Absorb Coefficient (Depends with frequency)

So , We have to use Octave Band Value to consider Insertion loss and vent length .Above formula is suitable with low frequency sound . (Wide of vent devide wave length less than 0.1) and flow velocities should less than 4,000 feet per minutes. Dissipative silencers in the market can be quadrilateral and sphere shape. And data of reducing valve in this table 2-1

Table 2.1 Dynamic insertion loss value and Air–flow–generated noise value of dissipative silencer (dissipative duct silencers)

Dynamic insertion loss								
Silencer shape	**Face Velocity (Feet per minutes)**	**Octave Band Frequency**						
		125	**250**	**500**	**1K**	**2K**	**4K**	**8K**
quadrilateral	750	13	28	36	39	40	39	27
long 5 feet	2,000	11	25	34	39	40	39	27
Sphere long	1,000	6	18	31	38	36	25	16
3 feet	2,500	5	15	28	35	33	24	14

2.6.2 Reactive Silencers [17]

This silencer can reduce sound by use geometric shapes such as adding more cross-section surface of vent to make impedance (Acoustic Impedance) change. The result is reflect sound energy at impedance was changed. Reactive silencer can reduce sound that has frequency not wide as first type. If want to sue this silencer to control sound , must consider about which frequency phase we want to control , then choose the relates one. However , we use silencer with low frequency sound. The first type is not good enough.

Basically , silencer that not complicated shape (Simple Reactive Silencer) can work by changing impedance or resistance of sound wave moving that came from cross-section surface sharp changing and acoustic resonance setting up inside expansion chamber. The changing of impedance made up impediment for sound energy forward. The sound wave inside chamber will reflect and cannot come out.

Pragmatically , Because we need to reduce more sound in many frequency phase. So, they produce more complicated silencer. We can found many chambers and hole include sound absorb material installation. For example , Expansion type silencer , Resonator type silencer.

2.6.2.1 Expansion type silencer.[18]

Expansion type silencer is reactive silencer. It can reduce sound by expand some phase of silencer to be cavity. Then can filter sound by reactive silencer' principle as Figure 2.9

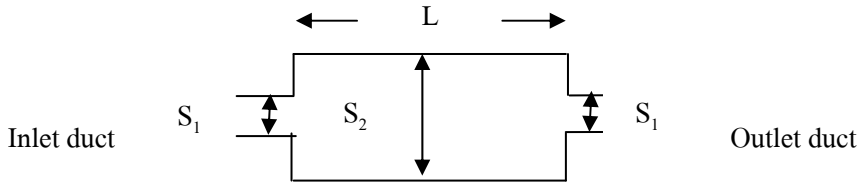


Figure 2.9 Expansion Silencer

This Figure shown Expansion type silencer as No. 2.9 is the most simple .The cross-section surface of inlet duct (S_1) and outlet duct (S_2) have same size . Calculate reducing value from equation 2.3

$$TL = 10\log\{1+ 0.25 [m - (1/ m)]^2 \sin^2 kl\} \text{ dB} \quad \text{..... equation 2.3}$$

When TL = Attenuation

m = roportion of cross – section surface and inlet cross –section surface from Figure 2.9 is S_2/S_1

k = $2\pi f/C$

L = Cavity length

C = sound speed

When KL = 1 found TL value at rate of S_2/S_1 or we call m value that shown in table 2.2

Table 2.2 TL of Expansion Chamber for KL = 1 [19]

m	5	10	20	40	80
TL, dB	8	14	20	26	32

For this design , m value and 1 will be different. And will effect to sound filter as Figure 2.10

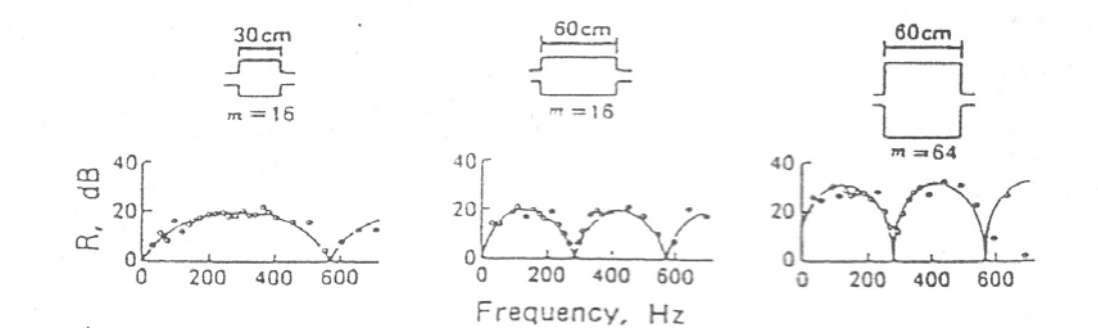


Figure 2.10 Expansion type silencer reducing for different cavity .

Figure 2.10 can shown that the effectiveness of this silencer can decrease or increase cycling follow by each frequency phase. When m value higher , this cycle

will be more frequency . Besides the high m value and low 1 value , we need to design in every sides of cavity that must be smaller than length of sound wave we control.

Silencer designs related with sound speed and high temperature gas will make more speed that can calculate from formula 2.4

$$C = 49.03\sqrt{(T(^{o}F) + 460)}\ ft/s \quad \text{..... Equation 2.4}$$

$$C = 20.05\sqrt{(T(^{o}C) + 273)}\ m/s \quad \text{.....Equation 2.4.1}$$

2.6.2.2 Resonator type silencer.[18]

Resonator type silencer is suitable for reduce sound in low frequency area that often has resonate problem. This silencer will be punched at the wall to be gap or hole from inlet to closed cavity as Figure 2.11

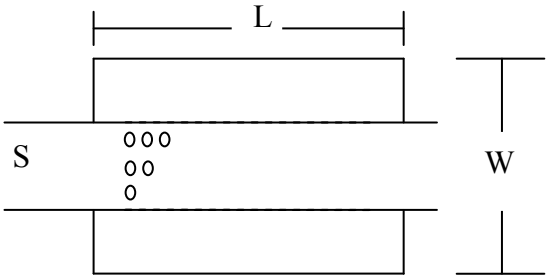


Figure 2.11 Resonator type silencer

Reducing sound by this type silencer happens from the air in cavity was closed. And it has cavity size smaller than sound wave length. It similar with spring. During the air around the opened cavity is mass that stuck on the spring's bottom. So , Air Mass will vibrate follow resonator value as the equation 2.5. The opened cavity and the air around the gap of this cavity can be resonator that we called "Helmholtz Resonator". When sound wave come and pass arrive resonator , the wave that has resonator comply with air mass vibration of opened cavity will make the air vibrate heavily and suck the wave at that resonator valve into cavity. The valve of sucking of this silencer at any resonator valve can calculate by equation 2.6

$f_r = (C/2\pi) * \sqrt{(NG/V)}$ Hz ..... equation 2.5

$R = 10\log [\ 1 + (NGV / 2S^2)]$ dB ..... equation 2.6

When f_r means resonator frequency value

R means Attenuation

N means Amount of opened gap to air cavity

V means cavity capacity

S means cross-section area

G means Air Conductivity per 1 opened gap in case it is circle gap G = s / (1+ 0.8d) when s means cross-section area of opened gap l means thickness of vent and d means opened gap diameter.

Can calculate attenuation at any sound frequency from formula 2.7

$$TL(f) = 10\log_{10}\left[1+\left(\frac{\sqrt{NGV/2S}}{\frac{f-fr}{fr\ \ f}}\right)^2\right] \quad \text{..... equation 2.7}$$

2.7 Retort Silencer.[12]

Silencer for attenuation of steam exhausting from retort , this invention relate to silencer use on bleeders of large cooking retorts as found in the caning industry, as follow figure 2.12

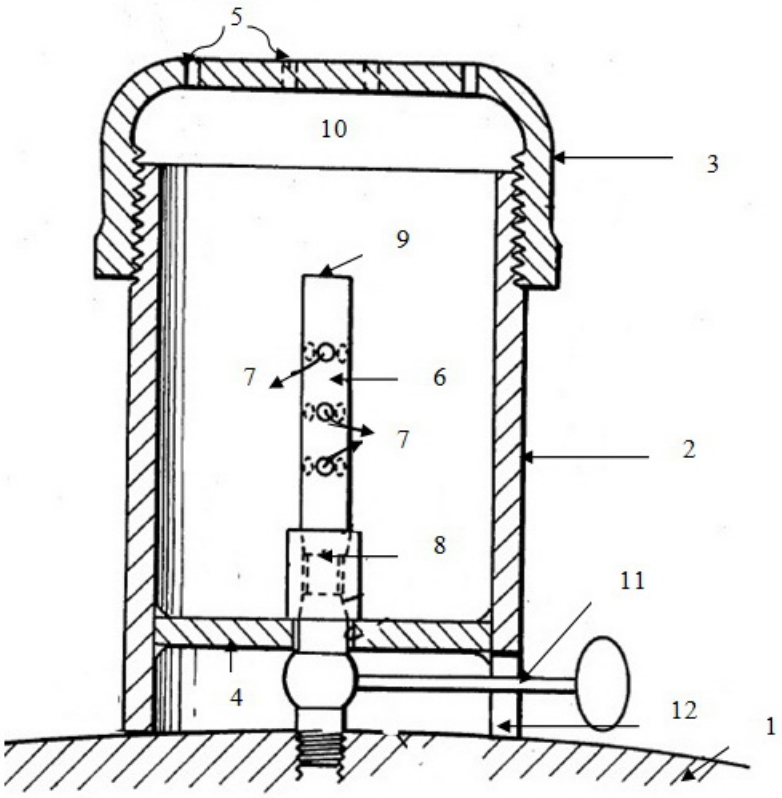


Figure 2.12 Schematic diagram of retort muffler

The description of the drawing is number 1 is retort top cover . The Top bleeder muffler comprise a hollow, cylindrical body 2, having top and bottom end closure 3,4, respectivity. The body may be conveniently made from 3-inch I.D. standard steel pipe nipple 5 inches long. The top end closure 3 can be 3-inch I.D. standard steel pipe and the top end closure 3 on a $^{1}/_{8}$ inch diameter bleeder. These latter perforations have been satisfactorily found to comprise $^{1}/_{8}$ inch diameter, equally spaced hole 5 with four on 1 inch diameter and four on a $2^{\frac{1}{2}}$ inch diameter hole circle, cylindrical pipe diffuser 6 having an open outer end 8 and a closed inner end 9. The diffuser has a plurality of holes or perforations 7 ranged along its length so as to laterally direct the steam into chamber 10. It has been inches long having nine $^{1}/_{8}$inch diameter holes in three 120^{o} grouping along the diffuser and the valve steam 11 extended through a side wall cutout to from a slot 12 to allow manual operation thereof.

2.8 Sound Level Measurement. [20]

Check sound level around silencer that far from silencer's vent 1 m angle 45° . Position of measure for cylindrical silencer should be follow dash line shown Figure 2.13

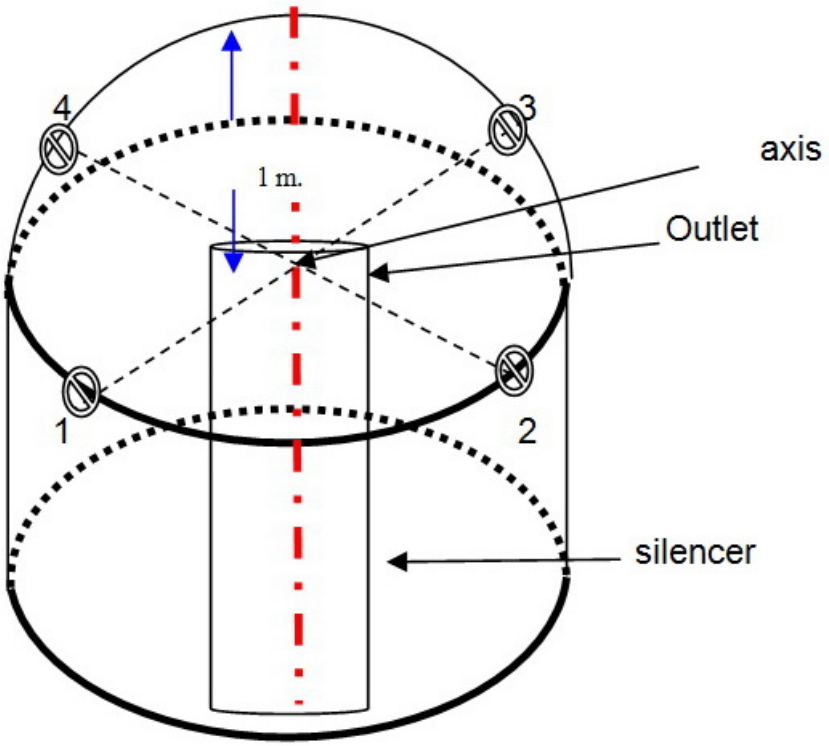


Figure 2.13 : Spherical surface in front of a silencer

By set microphone high 1 m from vent bottom that follow ISO 11820. The measure place must be plain, made from concrete or sound reflect able material (Free Field)[21] Far from nearly object 30 m at least that can protect reflection sound from them. Then , can calculate the average of sound value as follow this formula.

$$\overline{L_P} = 10\log[\ 1/N \sum_{j=1} 10^{\,0.1\ L_{pj}}]\ dB \qquad \text{....Equation2.8}$$

When L_{pj} is sound level in each point

N is The amount of sound measurement

2.9 Silencer working effectiveness evaluation. [20]

2.8.1 Insertion sound pressure level difference. (D_{ips} or IL)

It is a different value of sound level for 1 point or many points that already calculated average sound value (Equation 2.4) before and after silencer installation can calculate by equation 2.9

$$D_{ips} = L_{pII} - L_{pI} \quad dB \quad \text{..... Equation 2.9}$$

When L_{pI} is sound level that we got from measure in 1 point or many points that already calculated average sound value after silencer installation.

L_{pII} is sound level that we got from measure in 1 point or many points that already calculated average sound value but without silencer installation.

2.10 Background Noise. [20]

We do not need the background noise because we want to control sound level that came from the machine. In this case, we should measure sound level by octave band and measure sound during machine working and not working. If sound level during machine working higher than not working 10 dB , It means background noise has no affect to the genesis we study.

But if sound level from the background noise was different from the genesis we study less than 10 dB, minus sound level value with background noise value by table 2.3.

Table 2.3 : Correction for background noise

Difference between sound pressure level measured with sound source operating and background sound pressure level alone	Correction to be subtracted from sound pressure level measured with sound source Operating to obtain sound pressure level due to sound source alone
< 3	Measurement invalid
3	3
4	2
5	2
6	1
7	1
8	1
9	0.5
10	0.5
>10	0

2.11 The relate studies

Bhattacharya P, Panua R, Bose PK, Ghosh BB. 2008 [22] studied in reactive silencer design. (reactive silencer) to reduce noise from diesel engine's exhaust pipe 16 horse power , 4 cylinders . The noise from exhaust pipe will has high temperature and erode. And flow the solid partied that can destroy inside vent of silencer. Then affect to silencer's effectiveness. The design steps are 1. Design inlet duct has diameter equal with engine's exhaust pipe diameter. The length must be shortest as it can possible. 2. Design the chamber diameter by use formula that is rate of cross – sectional surface of diameter and cross – sectional surface area of inlet duct 3 set chamber length 10 – 12 times of inlet duct diameter. 4. Calculate wasting from transmission loss. The silencer has inlet duct diameter 63.5 mm , long 200 mm , thick 2 mm , diameter of chamber is 200 mm , long 750 mm , thick 3 mm , the bottom of vent equal with inlet duct. Measure sound during engine run 1,300 round / second at 1 m distance and 45 angle in silence room , found that sound level without silencer is

94.9 dB and new sound level that build up is 81.3 DB. The sound level can be reduced 15 dB by comparison with the old silencer. And Bhattachaya P, Ghos BB, Bose PK. 2010[23] studied in Transmission loss (TL). Found that the highest transmission loss is 13 dB from the designed silencer.

Bussey R J, Bussey, Almoo.1975 [12] studied about silencer from steam valve of high pressure retort. Found that silencer can be cylindrical shape that punched at top of vent. Inside vent, there are holes along the length of it and has water drain hole for water that came from steam condensation to reduce corrosion. From the silencer installation at bleeder, found that can reduce 10 – 11 dB(A) sound level. The equipment made of stainless steel for reduce corrosion and to be more clean.

Ghos BB, Bhattacharya P, Panua R, Bose PK. 2007[24] studied and try silencer that reduce diesel exhaust pipe engine sound. Design to cylindrical shape that has diameter 250 mm , long 700 mm and small cylindrical vent 2 pieces that have diameter 63.5 mm inside and punched the hole that has 5.0 mm diameter for 38 holes. Found that silencer can reduce sound in each frequency phase as 63 Hz, 125 Hz, 250 Hz and 500 Hz . Sound level reduced 18.025 dB , 18.025 dB, 16.47 dB and 16.4 dB.

Vasile O, Enescu N. 2009[25] studied in silencer effectiveness in style of Multi Chamber Silencer. The shape is cylindrical that has inside diameter 0.4 m , long 0.94 m and design the silencer has punched hole 3 types. There are A Type – punched around perimeter 1 line. Each hole has 0.01 m diameter and 0.31 m distance between the center of each other. B Type – punched hole at perimeter 3 lines. Each hole has 0.01 m diameter and 0.31 m distance between the center of each other. And C type – punched 5 lines at perimeter , each hole has 0.01 m diameter and 0.31 m distance between the center of each other. After measure wasting level from transmission loss (TL) of 3 types , found that C type can reduce better or has TL Valve higher than A and B Type.

Vasile O, Vladimir K. 2008[26] Studied efficiency sound reducing of silencer in reactive silencer 2 types. A Type (Has one chamber) is cylindrical shape and has inlet duct 0.01 m diameter , long 0.095 m and chamber diameter 0.04 m and 0.355 m length . B type (Has three chambers) has inlet duct long 0.095 m , diameter 0.01 m and chamber diameter 0.04 m and 0.355 m length . Inside the chamber was

separate to 3 chambers at 0.03 m point , 0.295 m point and 0.03 m point. After trial in silence room and measure sound with 2 types silencers , found that B Type can reduce more . Or wastes transmission loss (TL) higher than B type.

Vasile O.2002 [27] studied silencer for two factory 2 types that are A type – Expand vent that has diameter 1.5 m ,long 1.5 m and has inside 1 vent that punched. B type – Expand vent that has diameter 1.5 m ,long 1.5 m and has inside 6 vents that punched. The hole has diameter 10 mm for 12 holes / perimeter . Each hole has 30 angle for 23 rolls. Each rolls has distance 50 mm. Found that Transmission loss of silencer B type higher than A Type in average 20 dB at each phase of frequency 0 – 8000 Hz.

Ghos BB, Bhattacharya P, Panua R, Bose PK, Vaijanapurkar MY. 2008[28] Studied Resonative Silencer for diesel engine type Multi – Cylinder. By design silencer that has inlet duct diameter 200 mm connected with chamber that has diameter 250 mm, long 700 mm and inside has 2 vents with 63.5 mm diameter punched 38 holes 5.0 mm diameter . after testing , found that silencer can reduce efficiently in every frequency 63 Hz ,125 Hz and 500 Hz . Can reduced 18.025 dB , 18.025 dB ,16.47 dB and 16.4 dB.

Monazzam MR, Golmohammadi R, Nourollahi M, Bellah Fard SM. 2011[29] studied in sound level and design silencer evaluation for water drain in Petroleum Factory . By studied in Tehran Factory year 2008. Design silencer that made from Aluminum that has 2 layers for chambers. Long 500 mm , 200 mm diameter, thick 2.6 mm and inside vent has diameter 200 mm ,long 200 mm and punched hole 5 mm diameter . distance 7.4 mm. Because of sound measurement from genesis need to stop another genesis that affect to the sound studying. It cannot be done in this case. So , the researcher measure from steam vent and oil refine area. Measure from 10 points that far from the genesis 1.5 m. Found that the sound level are not different much. At sound value average 93 dB and at steam jet sound level average is 90.3 dB at 400 Hz .After installed silencer on steam jet , can found that sound level reduce 17 dB.

Suwandi D, Middelberg J, Byrne KP, Kesssissoglou NJ. 2005[30] Studied in muffler working evaluation from finding Transmission loss. Design muffler has inlet and outlet duct that have 52 mm diameter and connected with chamber. Chamber

long 540 mm , 156 mm diameter. Measure sound level by connect silencer and genesis. Then use 2 microphones . One connect with genesis and another one at outlet duct. After that , connect all equipment to interpretation machine to find FFT1 and FFT2 and calculate transmission loss value of muffler from formula TL = 10log FFT1/ FFT2. Found that transmission loss of 200 Hz, 400 Hz, 600 Hz, 800 Hz, 1000 Hz and 1200 Hz about 13 dB.

Crawford C J, CEng, Mimech E. 1988[31] considered about silencer's development to reduce sound of steam flowing from safety valve / relief valve. Found that in year 1960 , There was silencer A type - Labyrinth Silencer that consist of cylindrical structure steel and cap. It has bleeder beside and on top . Found that can reduce 5-10 dB (A) . B type - Multi-Tube Absorptive Silencer is the steel structure that consist of inside vent that has holes around and chambers. On top of chamber has many small vents that punched small holes around them and wrap with sound absorb material. Can reduce 15 – 20 dB (A). In year 1970 , found Silencer C type - Diffuser Only that consist of small vent inside. Punched small hole around vent and cover outside. Then can reduce 15 – 20 dB (A) . D type - Diffuser Absorptive consist of vent inside and punched small hole around them include cover vent that has small hole with sound absorb material wrapping around top and beside it. Can reduce 30 – 40 dB. E type - Multi-Stage Diffuser Silencer was designed to have many diffuser layers and punched small holes around vent in each layer. Then connected chamber on top and steam bleeder on top that can reduce 30 – 40 dB.

Zhao H, Deng Z.2012 [32] Studied the impact noise from pipes with a porosity of silencer. It was found that if the diameter of the aperture and the time of the pipeline according to the noise decrease. And the ratio of the diameter of the hole with duct area expansion (expansion muffler) has little effect on the noise.

Bortolussi, Ciccu et al. 2003[33] The study compares the volume of the water pressure at 70 Mpa of pressure as the pipe diameter 1.2 mm., And 0.5 mm. Increase the diameter of the pipe. The noise increase. Especially at low and mid frequencies.

CHAPTER III
MATERIALS AND METHODS

3.1 Study Design

This study is experimental design. “We collect data from trial with sound level measurement before and after silencer installation that has frequency as 31.5, 63, 125, 500, 1K, 2K, 4K, 8K and 16K Hz by order and sound pressure level

The model of this study is divided as 2 steps :

3.1.1 Design the silencer.

3.1.1.1 Design Inlet pipe silencer

Inlet pipe diameter must equal with diameter of genesis pipe bottom . In this case , is Bleeder that a diameter ¼ inch or S_1 = exhaust pipe diameter = ¼ inch

3.1.1.2 Design Expansion Chamber.

From the objective that we need to reduce sound 10 dB. So , we choose m = 10 , m rate of S_2 /S_1. We choose m value from table No.3 that shown transmission loss (TL) as the table 3.1

Table 3.1 : TL of Expansion Chamber for KL=1

m	5	10	20	40	80
TL, dB	8	14	20	26	32

Reference : Elden F. Ray , Industrial noise series part VIII Reactive silencer

from formula $m = \frac{\text{Diameter of expansion chamber, } S_2}{\text{Diameter of circular pipe, } S_1}$

$$m = \frac{\pi/4D^2}{\pi/4d^2}$$

D is Diameter of expansion chamber

d is Diameter of circular pipe

That has pipe diameter 6.35 mm at m = 10

$$D^2 = md^2$$

$$D = (10)^{½} \times 6.35 \text{ mm}$$

$$= 20.08 \text{ mm}$$

Normally , expansion chamber will have length 10-12 times of exhaust diameter of pipe.

$$L = (10 – 12)\, d$$

choose $L = 10d$

$$L = 10 \times 6.35 \text{ mm}$$

$$L = 63.5 \text{ mm}$$

This study of design, the length of chamber is 76.2 mm and inner diameter 54.66 mm , it has perforated tube 3 type as follow silencer A has perforated tube has inner diameter 6.35 mm, long 38.1 mm and hole inner diameter 4.75 mm , 30 hole. Silencer B has perforated tube inner diameter 6.35 mm, long 38.1 mm and hole inner diameter 4.75 mm , 60 hole and Silencer C has perforated tube inner diameter 6.35 mm, long 38.1 mm and hole inner diameter 8.76 mm , 9 hole as table 3.2 and 3.3

3.1.1.3 Design Outlet pipe.

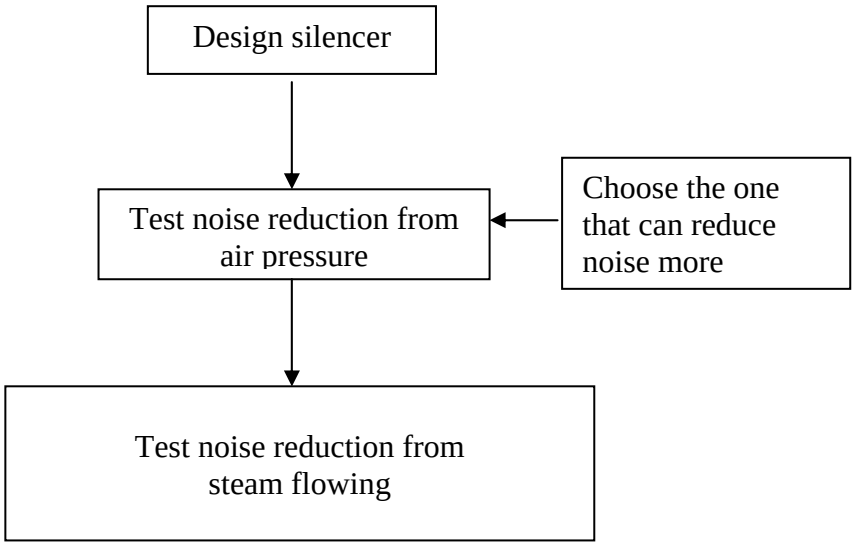
The top end closure that can be opened or closed. With hole away from diameter pipe 12.7 mm, hole with a diameter of 5.08 mm, 4 hole, drilled from the diameter of the pipe 25.4 mm, hole with a diameter of 5.08 mm, 8 hole, and, punching away from diameter pipe 38.1 mm, hole there 5.08 mm diameter and 12 hole.

3.1.2. Test performance of each silencer type.

3.1.2.1 Test sound pressure level from air pressure before and after silencer installation in free field with frequency 31.5, 63, 125, 500, 1K, 2K, 4K, 8K and 16K Hz by order and sound pressure level.

3.1.2.2 Choose the one that can reduce noise more to test with steam flowing at each frequency 31.5, 63, 125, 500, 1K, 2K, 4K, 8K and 16K Hz by order and sound pressure level.

The study design could be shown in Figure 3.1



1. Test sound pressure level
2. Test sound pressure level at each frequency

Figure 3.1 Study design

3.2 Examples Group

The examples group for the study is the noise that came from bleeder of retort . In 1 retort consist of bleeder 2 points for fish canned factory.

3.3 Material and Equipment

The material to use for fabricates the silencer such as

3.3.1 Stainless steel pip with an inner diameter (I.D.) 54.66 mm and thick 2.60 mm

3.3.2 Stainless steel plate 200 x 200 mm

3.3.3 Stainless round bar 54.66 mm I.D.

3.3.4 Stainless round bar 25.4 mm I.D.

The equipment to use for this test such as

1) Integrating sound pressure level meter, Quest model 1800
2) Serial No. HPA090013
3) Octave band filter , Model 1800
4) Integrating sound pressure level meter , Rion model NL-20
5) Serial No. 01099792
6) Silencer
7) Air pump , Air vent
8) Pressure gauge
9) Retort
10) Vernier Caliper
11) Data record

3.4 Experimental working

3.4.1 Design silencer as follows detail as follow Table 3.2**,** 3.3

Table 3.2 Shows the size of silencer type**.**

No.	Item	Diameter (mm)			Length (mm)			Thickness (mm)		
Silencer Type		A	B	C	A	B	C	A	B	C
1	Inlet Pipe	6.35	6.35	6.35	12.7	12.7	12.7	-	-	-
2	Perforated tube	6.35	6.35	6.35	38.1	38.1	38.1	13.46	13.46	13.46
3	Cylindrical Chamber	54.66	54.66	54.66	76.2	76.2	76.2	2.60	2.60	2.60
4	Hole	4.75	4.75	8.76	-	-	-	13.46	13.46	13.46

Table 3.3 The single perforated tube silencer.

Name	Orifice of length (mm)	Tube diameter (mm)	Tube Length (mm)	Hole diameter (mm)	Number of hole
A	38.1	6.35	38.1	4.75	30
B	38.1	6.35	38.1	4.75	60
C	38.1	6.35	38.1	8.76	9

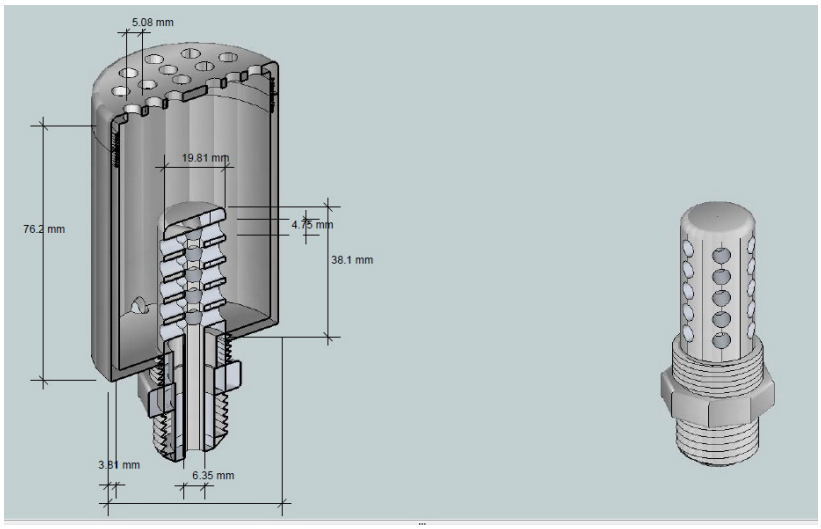


Figure 3.2 Schematic diagram of the silencer A

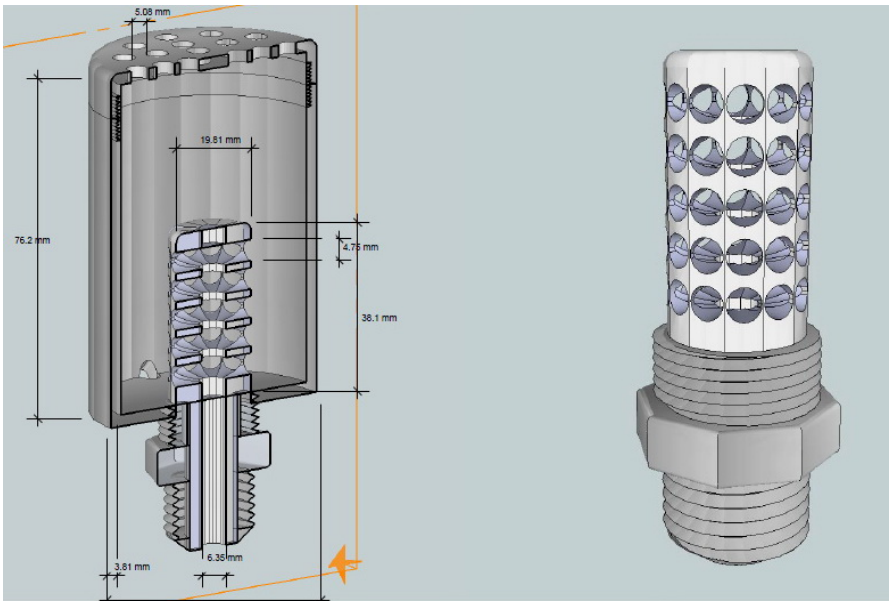


Figure 3.3 Schematic diagram of the silencer B

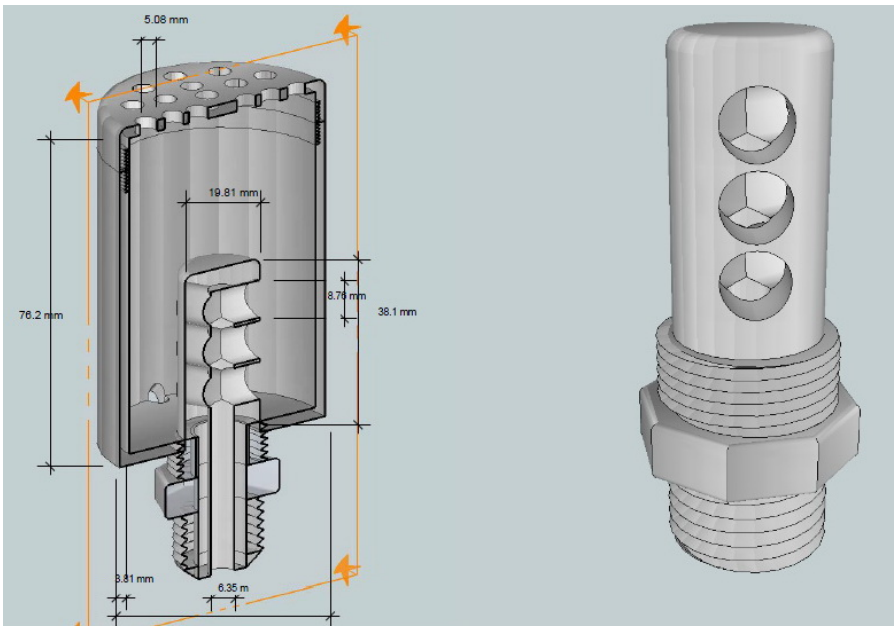


Figure 3.4 Schematic diagram of the silencer C

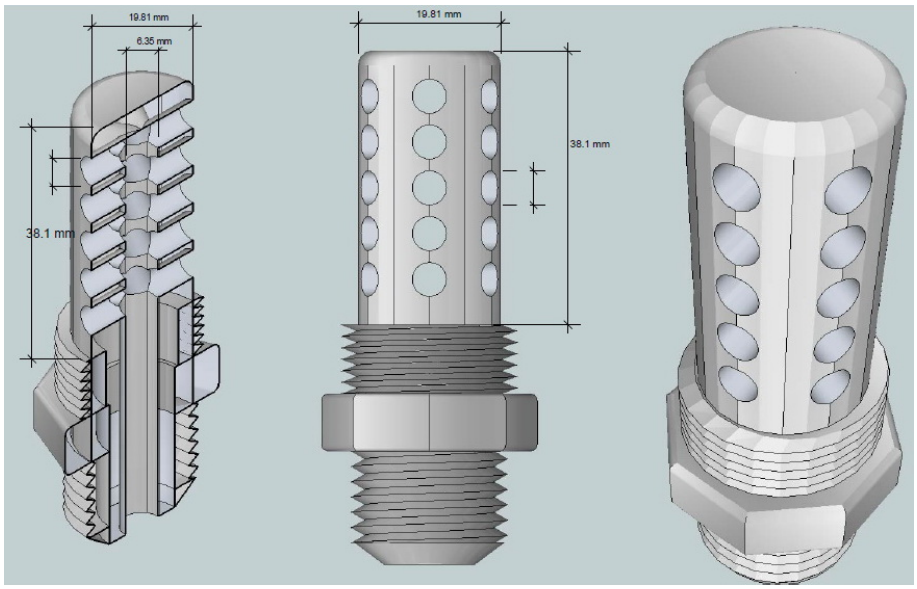


Figure 3.5 Perforated tubes of silencer

Figure 3.6 Perforated tubes in the single perforated tube silencer (from the left, A, B and C)

The cover that can be opened or closed. With hole away from diameter pipe 12.7mm hole with a diameter of 5.08 mm, 4 hole, drilled from the diameter of the pipe 25.4 mm hole with a diameter of 5.08 mm, 8 hole and punching away from diameter pipe 38.1 mm hole there 5.08 mm diameter hole 12 as shown in Figure 3.7

Figure 3.7 The silencer body and perforated with the cover.

Figure 3.8 Schematic diagram of the single perforated tube silencer.

3.4.2 Noise Measurement

3.4.2.1 Background noise measurement at free field.

3.4.2.2 The collect sound pressure level from air pressure when install bleeder and silencer. Connect it with steel stage from floor 1 m. Set microphone far from pipe 1 m. 45 degrees Celsius. Check for 4 points around the bleeder and silencer in each frequency 3 times that get 120 examples. And at sound pressure level for each 3 points that get 12 examples as Figure 3.9

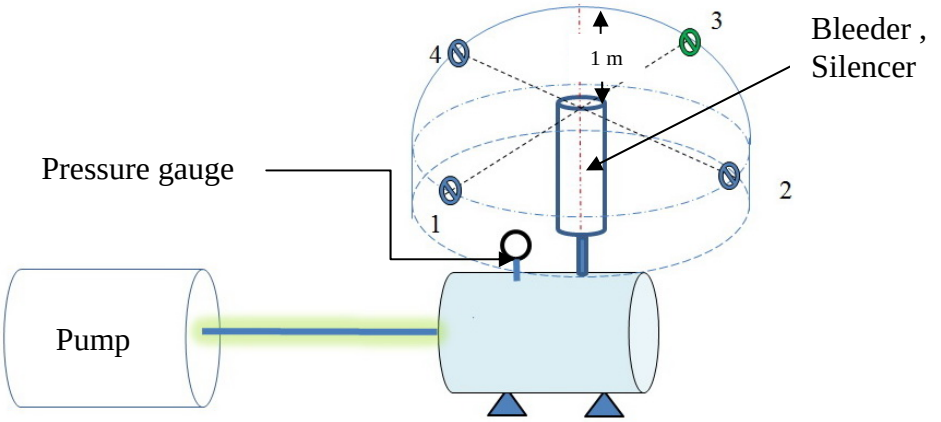


Figure 3.9 Location to measure noise reduction.

3.4.2.2 Set the air pipe by connect it with steel stage from floor 1 m. Set A Type silencer. Then check sound by set microphone far from pipe 1 m 45 degrees celsius. Check for 4 points around the valve in each frequency 3 times that get 120 examples . And at average volume 1 minute for each 3 points that get 12 examples. After finished, change silencer to be B, C type and try same as the Figure 3.9

3.4.2.3 Choose the better silencer to see at steam flowing valve 2 points. Then measure sound by set microphone far from pipe 1 m 45 degrees celsius Check volume 4 points in each frequency 3 times that get 120 examples at sound pressure level for 3 times in each point sampling (1,2,3,4 is the point of position sampling), that get 18 examples. The experiment is a retort at 116 C°, a

pressure of 12 PSIG and a maximum temperature used in sterilization of the retort in this retort by air will gradually raise the temperature until the required temperature is 116 C^{o} and went to the steam sterilization process. It is during this period that the Bleeder vent steam sterilization process will take approximately 25-30 minutes. as Figure 3.10 and 3.11

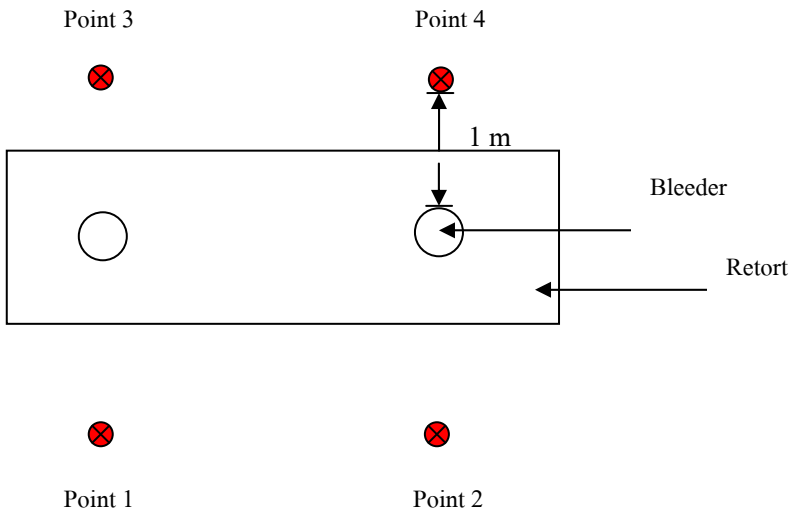


Figure 3.10 Location to measure noise reduction when install silencer and bleeder.

Figure 3.11 The points of sound pressure level before install silencer for noise reduction testing from retort.

3.4.2.4 Record data and compare noise reduction .

3.5 Static Analysis

Analyzed data by computer SPSS program version 16 static analyses are use as follow

3.5.1 Descriptive statistics

Mean and standard deviation are analyzing sound pressure level.

3.5.2 Inferential Statistic

T-test, F-test ANOVA, One Sample Test

- Compare sound pressure level between install silencer A, B , C and bleeder.

CHAPTER IV
RESULTS

The objectives of this research are study the efficiency of noise attenuation of silencer type A, B, C from air pressure. That noise reduction higher and not exceed 85 dB. Then we choose silencers that can reduce noise more to try with steam later.

The results of this study are divide into 2 parts as follows :

Part I Noise attenuation from air pressure of silencer type A,B and C

- Noise attenuation of silencer A
- Noise attenuation of silencer B
- Noise attenuation of silencer C

Part II Compare the sound pressure level between installed silencer each type.

- Compare the sound pressure level between installed silencer A, B,C
- Compare the sound pressure level between installed silencer A and B
- Comparison of sound attenuation of steam exhausting from retort between installed bleeder and silencer.

Part I Noise attenuation from air pressure of silencer type A,B and C

The result of measured sound pressure level and noise at each frequency**.** When installed bleeder and silencer at pressure 20 PSIG at a distance 1 meters, total 528 samples, The results as follow.

4.1 Noise attenuation of silencer type A

The noise reduction is vary depends on dimension of silencer and hole diameter of inlet pipe. As the silencer A has perforated tube inner diameter 6.35 mm, length 38.1 mm, thickness 13.46 mm and hole diameter 4.75 mm, 30 holes and

chamber diameter 54.66 mm and length 76.2 mm. The results of the experiments showed that silencer type A, it can reduced noise about 10.2 dB and noise reduction all frequency, Particularly high frequency noise reduction are 12.1, 12.1, 14.3, 13.9 and 8.8 dB at frequencies (Hz) 1K,2K, 4K, 8K, 16K , show results as Table 4.1 , 4.2 and Figure 4.1, 4.2

Table 4.1 Noise attenuation from air pressure at each frequency of silencer type A

Item	**Octave band center frequency (Hz)**									
	35	**63**	**125**	**250**	**500**	**1K**	**2K**	**4K**	**8K**	**16K**
Bleeder (dB)	70.7	70.4	69.8	62.8	59.7	68.7	75.8	84.7	88.5	88.3
Silencer A (dB)	65.5	65.9	62.7	56.7	56.5	56.6	63.7	70.4	74.6	79.5
Noise Reduction (dB)	-5.2	-4.5	-7.1	-6.1	-3.2	-12.1	-12.1	-14.3	-13.9	-8.8

Table 4.2 Sound pressure level of air pressure when install silencer A

Item	SPL (dB)
Bleeder	90.5
Silencer A	80.3
Noise Reduction	-10.2

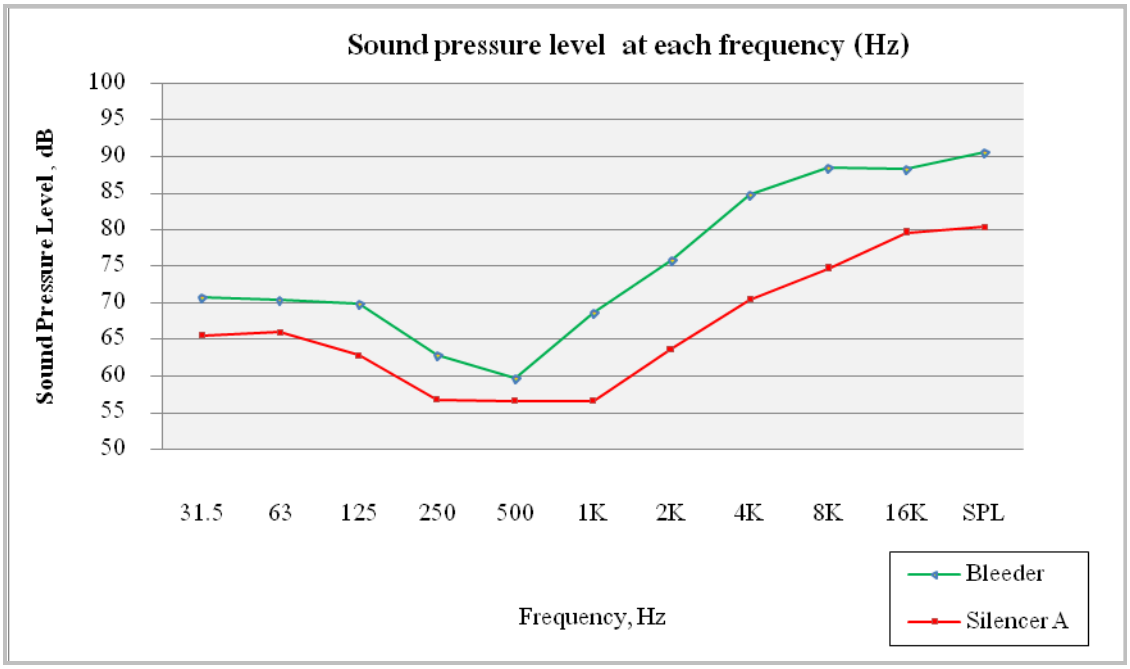


Figure 4.1 Comparison the sound pressure level at each frequency between installed bleeder and silencer A

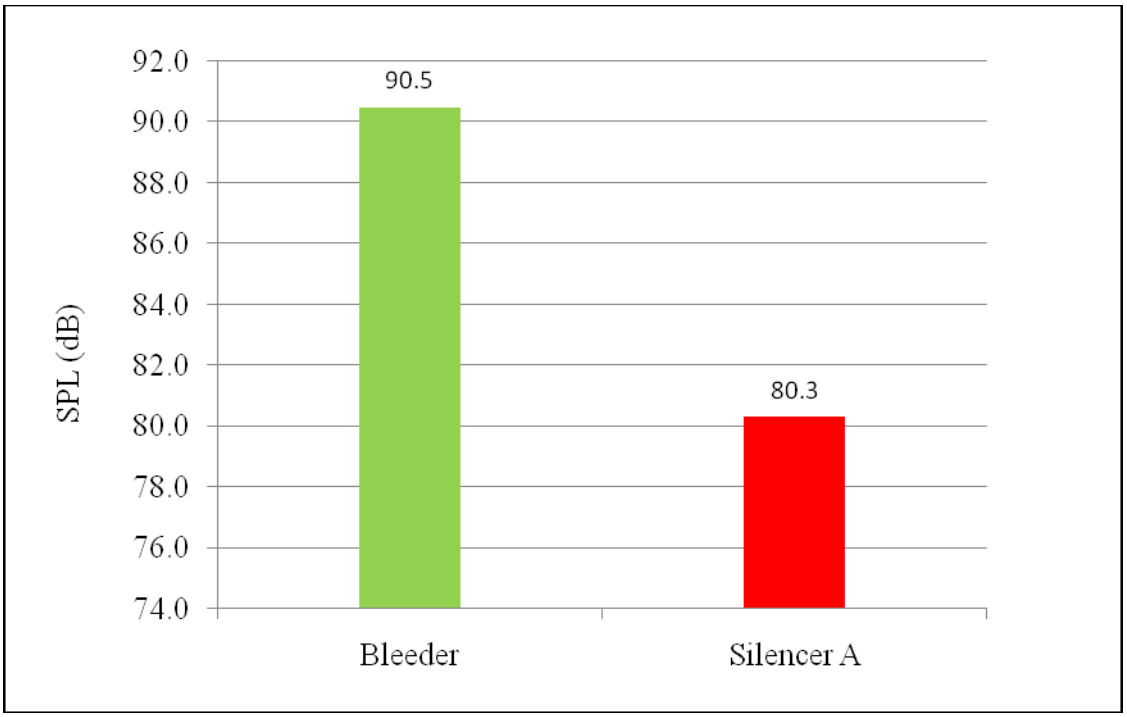


Figure 4.2 Comparison the sound pressure level between installed bleeder and silencer A

4.2 Noise attenuation of silencer type B

Silencer B has perforated tube inner diameter 6.35 mm, length 38.1 mm, thickness 13.46 mm and hole diameter 4.75 mm, 60 holes and chamber diameter 54.66 mm and length 76.2 mm. The results of the experiments showed that silencer type B, it can reduced noise about 9.1 dB and noise reduction all frequency, Particularly high frequency noise reduction are 12.0, 9.4, 9.8 and 6.9 dB at frequencies (Hz) 1K,2K, 4K, 8K, 16K , show results as Table 4.3, 4.4 and Figure 4.3, 4.4

Table 4.3 Noise attenuation from air pressure at each frequency of silencer type B

Item	**Octave band center frequency (Hz)**									
	35	**63**	**125**	**250**	**500**	**1K**	**2K**	**4K**	**8K**	**16K**
Bleeder (dB)	70.7	70.4	69.8	62.8	59.7	68.7	75.8	84.7	88.5	88.3
Silencer B (dB)	66.7	66.0	63.6	59.4	56.6	59.6	63.8	75.3	78.7	81.4
Noise Reduction (dB)	-4.0	-4.4	-6.2	-3.3	-3.1	-9.0	-12.0	-9.4	-9.8	-6.9

Table 4.4 Sound pressure level of air pressure when install silencer B

Item	**SPL (dB)**
Bleeder	90.5
Silencer B	81.4
Noise Reduction	-9.1

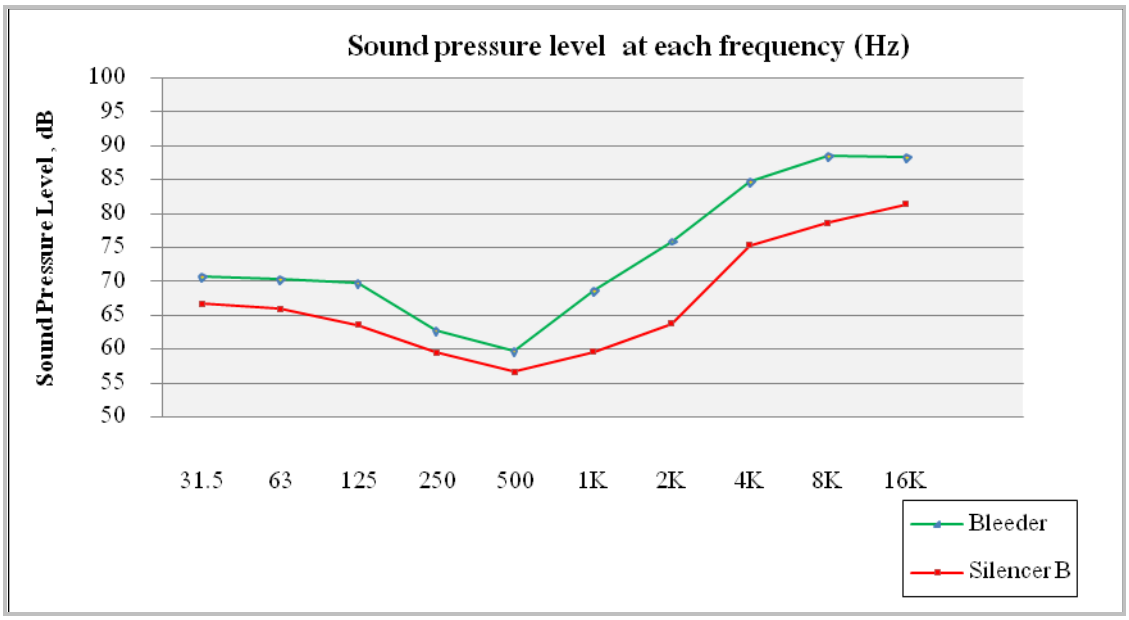


Figure 4.3 Comparison the sound pressure level at each frequency between installed bleeder and silencer B

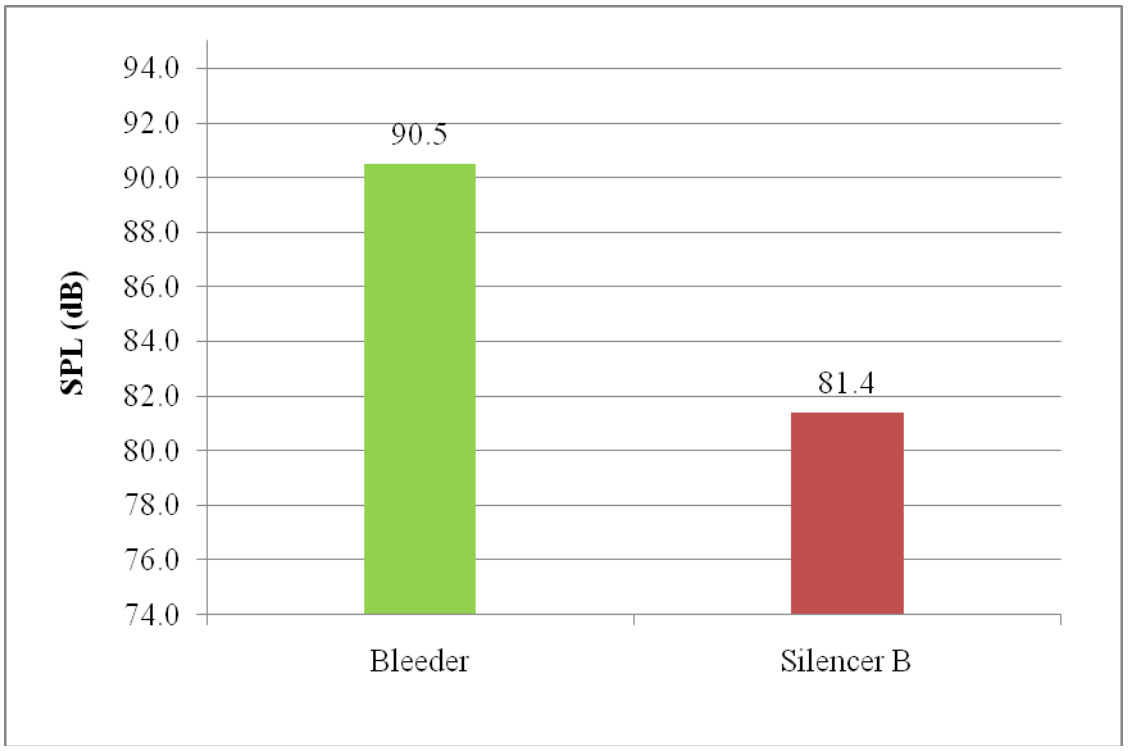


Figure 4.4 Comparison the sound pressure level between installed bleeder and silencer B

4.3 Noise attenuation of silencer type C

Silencer C has perforated tube inner diameter 6.35 mm, length 38.1 mm, thickness 13.46 mm and hole diameter 8.76 mm, 9 holes and chamber diameter 54.66 mm and length 76.2 mm..The results of the experiments showed that silencer type C, it can reduced noise about 5.8 dB and noise reduction are 92.2, 3.9 and 4.6 dB at frequencies (Hz) 4K, 8K, 16K , show results as Table 4.5, 4.6 and Figure 4.5, 4.6

Table 4.5 Sound pressure level of air pressure when install silencer C

Item	Octave band center frequency (Hz)									
	35	**63**	**125**	**250**	**500**	**1K**	**2K**	**4K**	**8K**	**16K**
Bleeder	70.7	70.4	69.8	62.8	59.7	68.7	75.8	84.7	88.5	88.3
Silencer C	73.3	73.9	73.4	63.7	62.5	69.5	75.6	82.5	84.6	83.7
Noise Reduction	+2.6	+3.5	+3.6	+0.9	+2.8	+0.8	-0.1	-2.2	-3.9	-4.6

Table 4.6 Sound pressure level of air pressure when install silencer C

Item	SPL (dB)
Bleeder	90.5
Silencer C	84.7
Noise Reduction	-5.8

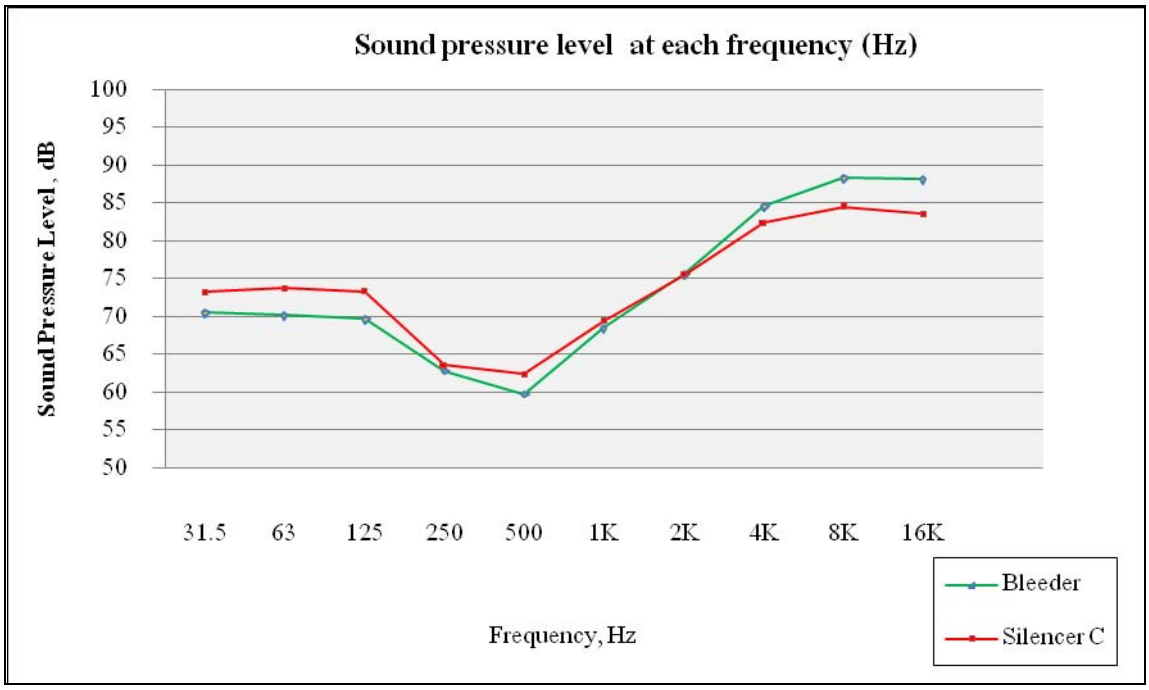


Figure 4.5 Comparison of the sound pressure level at each frequency between installed bleeder and silencer C

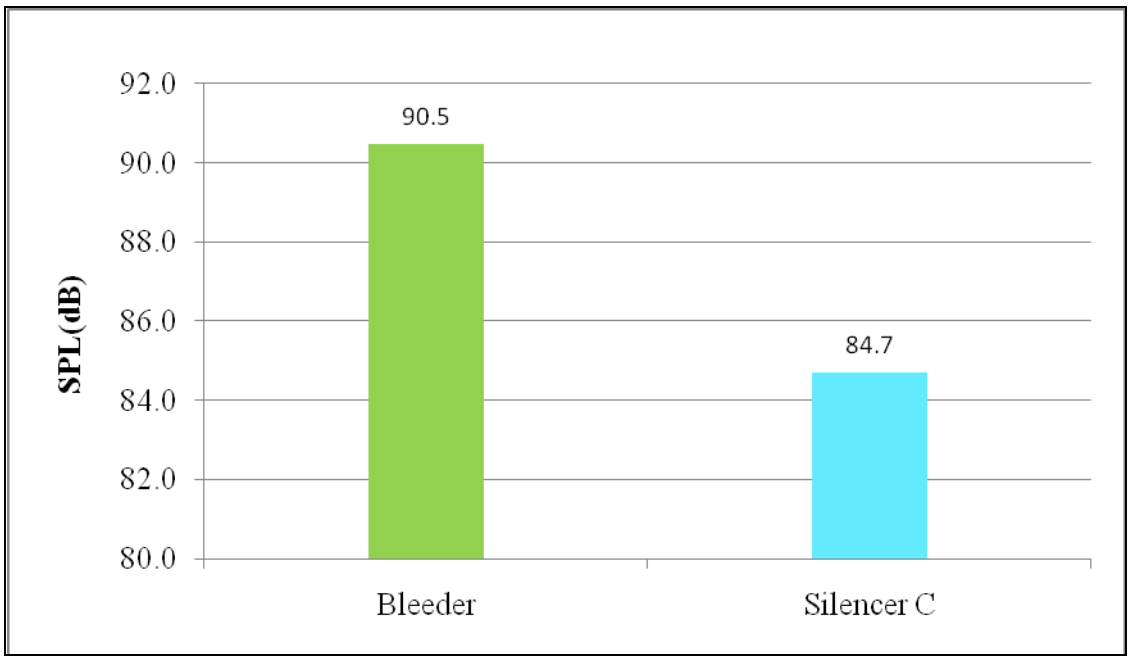


Figure 4.6 Comparison of the sound pressure level between installed bleeder and silencer C (n= 12)

Part II Compare the sound pressure level between installed silencer each type.

4.4 Compare the sound pressure level between installed silencer A , B and C

Hypothesis : The silencers from design can reduce noise of air pressure 10 dB at least. The study results comply the hypothesis when compare the sound pressure level between install silencer type A, B ,C and bleeder at air pressure. The results show that the sound pressure level from silencer type A can reduce noise more than silencer type B and C , respectively , show that in Table 4.7 and Figure 4.7

Table 4.7 Comparison of average of sound pressure level when install silencer A , B and C

Silencer Type	n	$\bar{x}$	SD	SE	df	t-test	P-value
A	12	79.22	0.16	0.046	11	-2.702	<0.001
B	12	80.27	0.20	0.058	11	15.758	<0.001
C	12	83.52	0.28	0.081	11	51.128	<0.001

Table 4.7 shows the comparison of the average of sound pressure level. The results show that the sound pressure level from silencer type A can reduce noise more than or equal to 10 dB, the silencer type B and C can not reduce noise greater than or equal to 10 dB significantly. (P-value <0.001)

Estimate of the sound pressure level, it found that in dB the silencer A has equivalent continuous sound pressure level between 79.36 - 79.12 dB, the silencer B has equivalent continuous sound pressure level between 80.39-80.14 dB and silencer C has equivalent continuous sound pressure level between 83.64 – 83.39 dB significantly. (P-value <0.001), which shows that silencer three type has sound pressure level not excess 85 dB. This is in accordance with the law and not harmful to hearing.

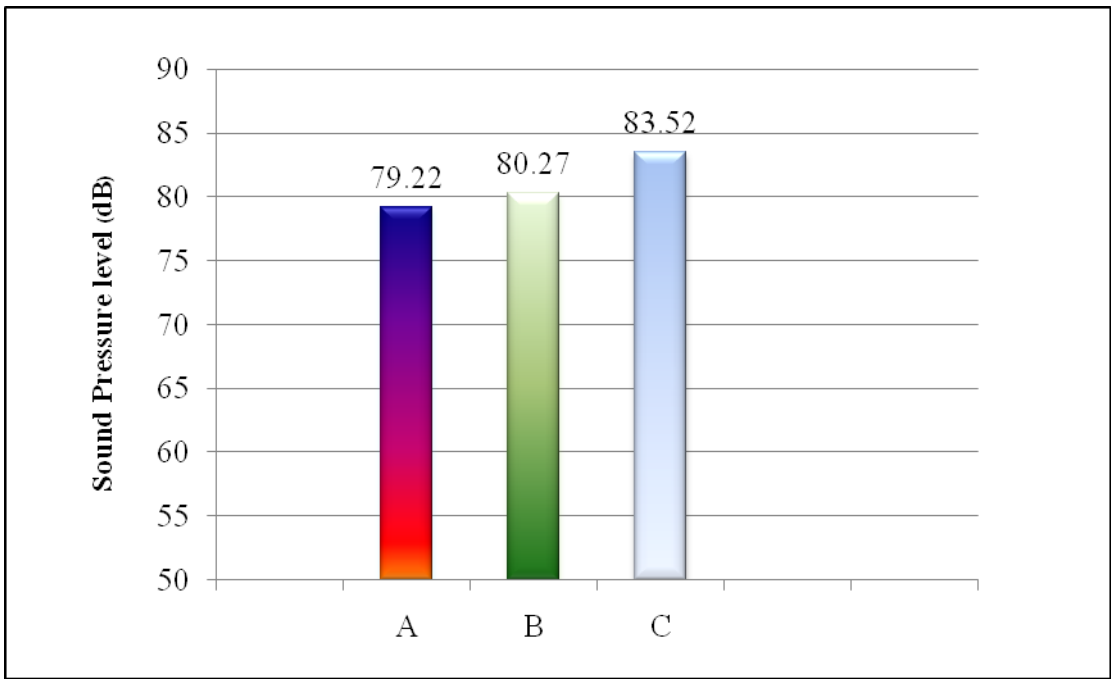


Figure 4.7 Compare the sound pressure level between install silencer A,B and C (n= 12)

4.5 Compare the sound pressure level of each type of silencer (A, B, C)

Hypothesis : The total area of the air holes is greater than the noise.

The silencer A has perforated tube inner diameter 6.35 mm, length 38.1 mm, thickness 13.46 mm and hole diameter 4.75 mm, 30 holes and chamber diameter 54.66 mm and length 76.2 mm, silencer B has perforated tube inner diameter 6.35 mm, length 38.1 mm, thickness 13.46 mm and hole diameter 4.75 mm , 60 holes and silencer C has perforated tube inner diameter 6.35 mm, length 38.1 mm, thickness 13.46 mm and hole diameter 8.76 mm, 9 holes. The results of the experiments showed that silencer A can reduce noise more than silencer B and C show the results of the comparison in Table 4.8 and Figure 4.7

Table 4.8 Comparison of average of sound pressure level when install silencer A , B and C

Silencer Type	n	$\bar{x}$	SD	df	F-test	P-value
A	12	79.22	0.16			<0.001
B	12	80.27	0.20	2.33	123.6	<0.001
C	12	83.52	0.28			<0.001

Table 4.8 is compare the sound pressure level between install silencer A, B and C at air pressure 20 PSIG, it found that the silencer A can reduce noise more than silencer B and C significantly. (P-value < 0.001)

By comparison, the duality between silencer A, B and C, the silencer A can reduce noise more than silencer B and the silencer A can reduce noise more than silencer C have significant (P-value <0.001) , silencer B can reduce noise more than silencer C have significance (P-value <0.001).

From the hypothesis the total area of the air holes is greater than the noise, it found that silencer B has total perforate area more than silencer A but the study result, it found that silencer A can reduce noise more than silencer B .

4.6 Comparison of sound attenuation of steam exhausting from retort between installed bleeder and silencer A

Hypothesis : The silencers from design can reduce noise of steam flowing 10 dB at least.

The experiments showed that silencer type A has the best capability to reduce noise. So to try to reduce the noise of the exhaust steam retort. The experiment baking retort at 116 degrees , pressure 12 PSIG no food in retort.

The experimental measurement of sound pressure level while installing bleeder and while installing silencer A, it found that silencer A can reduce noise 13.2 dB and noise reduction was 7.2, 12.8, 14.7, 17.0, 17.7 dB, the frequency of 1K, 2K, 4K, 8K and 16K respectively to compare the bleeder with silencer, it found that

Silencer's work is not different from the bleeder, which concluded that the silencer instead bleeder by not affect the sterilization of canned food in the retort. The measured sound pressure level as shown in Table 4.8, 4.10,4.11, and Figure 4.8, 4.9.

Table 4.9 Comparison of sound pressure level of steam exhausting from retort between installed bleeder and silencer A.

Item	SPL (dB)
Bleeder	92.2
Silencer A	79.0
Noise Reduction	-13.2

Table 4.10 Comparison of sound pressure level at each frequency of steam exhausting from retort between installed bleeder and silencer A.

Item	Octave band center frequency (Hz)									
	35	**63**	**125**	**250**	**500**	**1K**	**2K**	**4K**	**8K**	**16K**
Bleeder	68.1	67.2	65.9	62.1	65.0	69.2	76.8	84.1	88.2	87.0
Silencer A	64.4	61.5	62.0	59.5	59.7	61.9	64.0	69.4	71.2	69.3
Noise Reduction	-3.6	-5.7	-3.9	-2.6	-5.3	-7.2	-12.8	-14.7	-17.0	-17.7

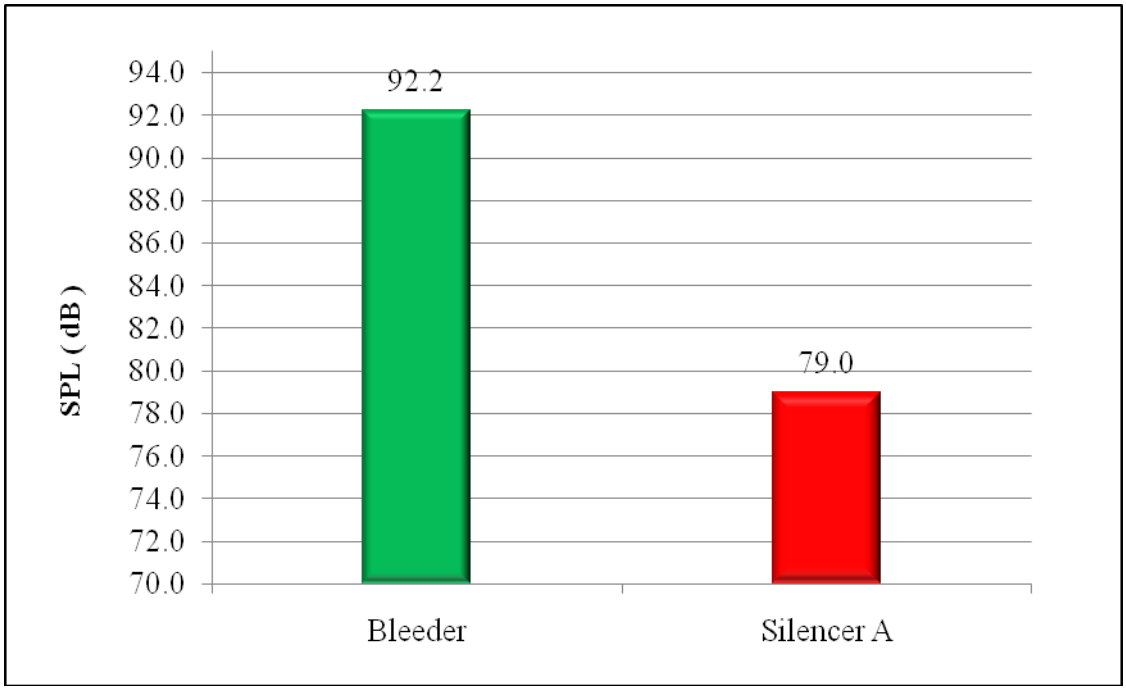


Figure 4.8 Comparison of sound pressure level of steam exhausting from retort between installed bleeder and silencer A. (n= 12)

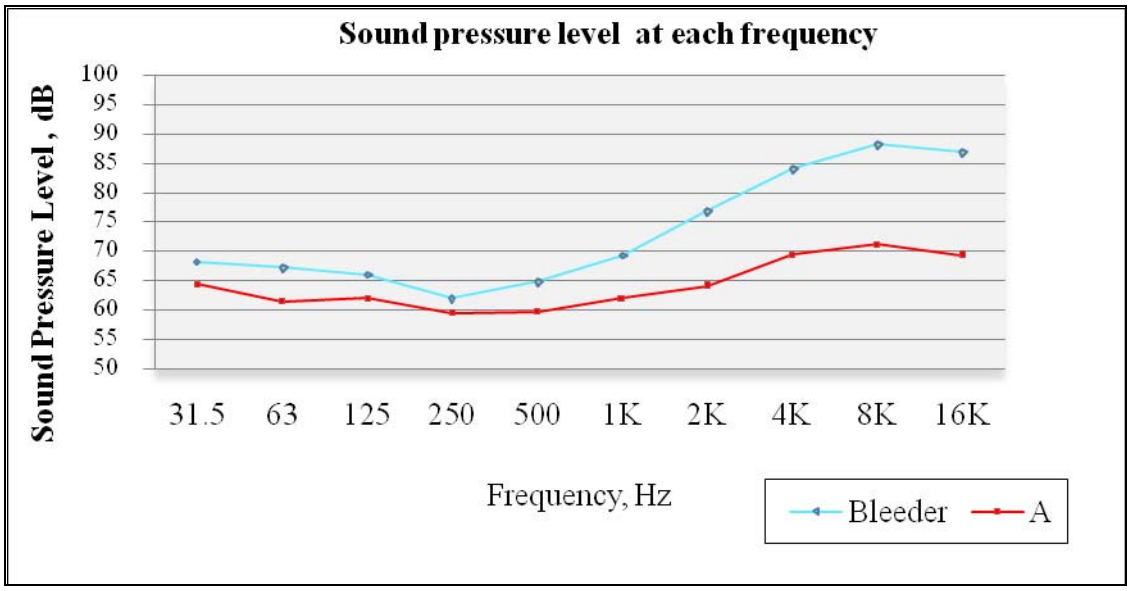


Figure 4.9 Comparison of sound pressure level at each frequency of steam exhausting from retort between installed bleeder and silencer A

Table 4.11 Compare the average of sound pressure level between install silencer A and bleeder on retort

Item	n	$\bar{X}$	S.D.	df	t-test	P-value
Silencer A	12	76.73	1.28	22	28.58	<0.001
Bleeder	12	90.22	1.02			

Table 4.11 shows the sound pressure level of silencer A , it found that silencer A can reduce noise more than the bleeder 13.2 dB have significance (P-value <0.001).

CHAPTER V
DISCUSSION

5.1 Discussion of Study Design

This Study is an experimental study that to study for noise reducing from air blow. In case silencers type A,B and C installation . And to compare reducing ability for steam exhaust noise reducing of sterilizations.

5.1.1 Silencer design : We designed by calculate transmission losing values (TL) that we have steps as 1) Design Inlet pipe 2) Design Expansion Chamber 3) Design Outlet pipe that follow the transmission losing values calculation principles. Mostly , we study noise reducing from automobile exhaust. But in this study ,we designed silencers that different from theory because we need to reduce steam exhaust noise . So , the researcher tried to find the design noise reducing equipment that most suitable with the study case and maintain to design for noise reducing. So that had no Transmission loss calculation for support in this study.

5.1.2 Silencers making process : In this process might be some mistakes for each inside hole drilling. For each hole in inlet pipe that might be not same sizes , not to be much circle shape that affected to noise reducing. In this process we use vernier calipers to measure the sizes , deep and length of objects. If the designed equipment not to be standard , we must to make a new one instead. So , it made us to remake silencers many times. And drilling process for silencers inlet pipe must to be have same diameter with bleeder. In this experimentation , we have 0.25 inch diameter length because if it not same with the old one it will affect to air or steam blowing.

5.1.3 Thickness of drilled inlet pipe: Because of the theory, mostly designed silencers should not much thick but in this study case it must to thick

because we must make same size spiral with Bleeder spiral . And for high pressure durable ,too. The thickness of inlet pipe can affected to silencers noise reducing.

5.2 Systematic Error

5.2.1 Personal Error : This error can happen during noise from air that about the position of measure point , Microphone angle setting and error air pressure from adjusting by human. From this errors , the researcher tried to do corrections by use the sticks that same high with measurement distance to set the 4 points that were vertical with each measure point. So ,it easy to adjust microphone angle to be 45 degrees . For air pressure adjusting problem , can be solved by waiting for the pressure get inside the making pressure tank first. Then , blew the air along with air pipe and wait until its stable. After that , started to measure noise. If the pressure went down during experiment, The researcher will cancel that case and try a new case.

For making silencers measurement can be error because we use human who did not stable like automatically equipment.

5.2.2 Condition Error : We measure noise in the field that far from near object at least 30 meters to protect surrounding sound reflection. It must be no reflection from any nearly object or any noise in the experiment place. Sometimes it had noise from cars and some effects from wind. In this case , the researcher will start experiment again and cancel the old results during noise. During studying , we use sponge to covered on microphone for wind and steam protection.

In case noise measurement from steam bleeding of retort , found that at the point of measurement had finite factors because they had another equipment and wall beside the experimental place. One side of machine is a wall that can be reflection sound at wall area. Can effected to be more higher level noise than the side that not next to the wall. So , we solved it by measured all 4 points first , then we calculated by average value. But from the experimentation , can found that “ noise can be reduced

more than 10 dB in every points. We tried this case just one time because the finite factors about retort and steam generator budget that very high.

5.3 Discussion of Study Results

5.3.1 Noise reducing from Bleeder and Silencer during installation comparison

Hypothesis : The silencers from design can reduce noise of air pressure 10 dB at least. We found that all 3 types of silencers can reduce noise from air and can control not to be over 85 dB as law. Silencer A can reduce 10.2 dB that follow the theory " If diameter of jet outlet is big we get low frequency noise but if its small the pipe that had low frequency noise can be changed to be high frequency noise by use many small pipes instead of only one outlet pipe. And we got result that is the high frequency noise that easy to control. If the pipe was expanded or had some gaps , we got less volume for low frequency noise. If its more big gap , more reduce volume for lower frequency noise . But for wide phase sound that has wide frequency , must have many gaps to reflect . So, using small hole drilled pipe can help to reduce noise by reflection.

5.3.2 Noise reducing from Silencer A and B during installation comparison

Hypothesis : The total area of the air holes is greater than the noise.

We found that Silencer A and B can reduce sound nearby. In spite of the had different numbers of air blow gap. From this result , it is not follow to the hypothesis. Because drilling many small holes made much sound flowing rate. (Q=AV) When altogether , made much more volume at the same pressure that comply with the study of effectiveness from muffler's porous pipe that if we reduced the diameter of hole and reduced length , we can reduce noise. And the rate of drilled pipe diameter and expansion muffler space can effect to loud sound generate insignificant.

5.3.3 Compare results of noise reducing between Silencer A and C during installation

Can found that Silencer C and can reduce noise less than Silencer A that comply with theory " At the same pressure , more bigger of diameter can made more loud sound. Especially , at low frequency and middle frequency . If reduced hole diameter and length of pipe in silencer , can reduce noise .Because normally silencer design , the pipe must have diameter bigger than drilled hole. But the our designed silencers have pipe diameter very small that is 6.35 mm. The drilled hole have 8.76 mm. That can reduce noise little when compare with Silencer A that was drilled hole 4.76 mm diameter.

5.3.4 Silencer A can reduce noise from steam 10 dB at least.

Hypothesis : The silencers from design can reduce noise of steam flowing 10 dB at least. From the experiment that measured noise during Silencer A installation on retort instead bleeder . Found that silencer can reduce sound 13.2 dB . We can see that in the same silencers but can reduce noise from steam bleeder better than air pressure. Because we could not try in the same situation. We found that noise from air pressure measurement that during installed bleeder is lower than from retort's bleeder because the measurement noise from the retort is the install bleeder 2 points, resulting in a noise higher than the experimental pressure.

CHAPTER VI
CONCLUSION AND RECOMMENTDATION

6.1 Conclusion

The purpose of the study is to study sound reducing when installed silencer that we designed. We tried at 20 PSIG air pressure and checked sound level at 1 meter height from the end of pipe and at the average sound level for 1 minute. And at the frequency 31.5, 63, 125,250, 500, 1K, 2K, 4K, 8K and 16K Hz . We can conclude as follow.

6.1.1 Silencer type A has the best capability to reduce noise. From the results of bleeder's noise average it is 90.5 dB. From the results of silencer A's noise average it is 80.3 dB that can reduce noise 10.2 dB and 12.1, 12.1, 13.9, 14.3 and 13.9 dB that has frequency from 1K,2K, 4K, 8K, 16K by order at 20 PSIG air pressure. So , it suitable for retort's steam bleeding noise reducing experimentation.

6.1.2 Silencer type B has the second capability to reduce noise from type A. From the results of bleeder's noise average it is 90.5 dB. From the results of silencer B's noise average it is 81.4 dB that can reduce noise 9.1 dB and 9.0, 12.0, 9.4, 9.8 dB that has frequency from 1K, 2K, 4K, 8K, 16K by order at 20 PSIG air pressure.

6.1.3 Silencer type C has the least capability to reduce noise from all 3 types .From the results of bleeder's noise average it is 90.5 dB. From the results of silencer C's noise average it is 84.7 dB that can reduce noise 5.8 dB and 2.2, 3.9, 4.6dB that has frequency from 4K, 8K, 16K by order at 20 PSIG air pressure.

6.1.4 Silencer A can reduce noise from steam bleeding in retort 13.3 dB and can reduce sound 7.2, 12.8, 14.7, 17.0, 17.7 dB at frequency 1K, 2K, 4K, 8K and 16K respectively. From bleeder and silencer results comparison found that silencer can work same with bleeder at retort process 116 Celsius degrees and pressure 12 PSIG .

6.2 Recommendation of Future Study

6.2.1 Should design bleeder from 2 sets or more . If remain 1 set , can make steam bleeder hole bigger that make more loud noise . Then install silencer to reduce noise.

6.2.2 The sizes of silencer quite big. The next study , should be more reduce size 20% by keeping same size of the old steam bleeding hole and try to design nearby the old one.

6.3 Recommendation for Using Silencer

6.3.1 Before use silencer instead of bleeder , make sure that we already tried with temperature , pressure and period of sterilization .Because we only design this equipment for retort at 116 Celsius degrees and pressure 0.85 kg/cm^2 .

6.3.2 If would like to use the designed silencers, must study about the diameter of air blow hole at pipe's ending first. Because this trial , we study in 0.25 inch of pipe diameter.

6.3.3 Before use silencer, must check the silencer's spiral because bleeder's spiral for each retorts are not the same size.

6.3.4 Because silencer of sound reducing can be happened from steam bleeding that passed small holes in pipe. So it can be clogged and has sediment in silencer . So , should check and clean up silencer.

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APPENDIX

PICTURE OF SILENCER AND NOISE MEASUREMENT

Figure A-1 Bleeder

Figure A-2 Silencer Type A, B, C

Figure A-3 The Body and Cover of Silencer Type.

Figure A-4 The test sound pressure level from air pressure while install bleeder

Figure A-5 The test sound pressure level from air pressure while install silencer

Figure A-6 The points of sound pressure level before install silencer for noise reduction testing from retort.

Figure A-7 Install silencer on retort.

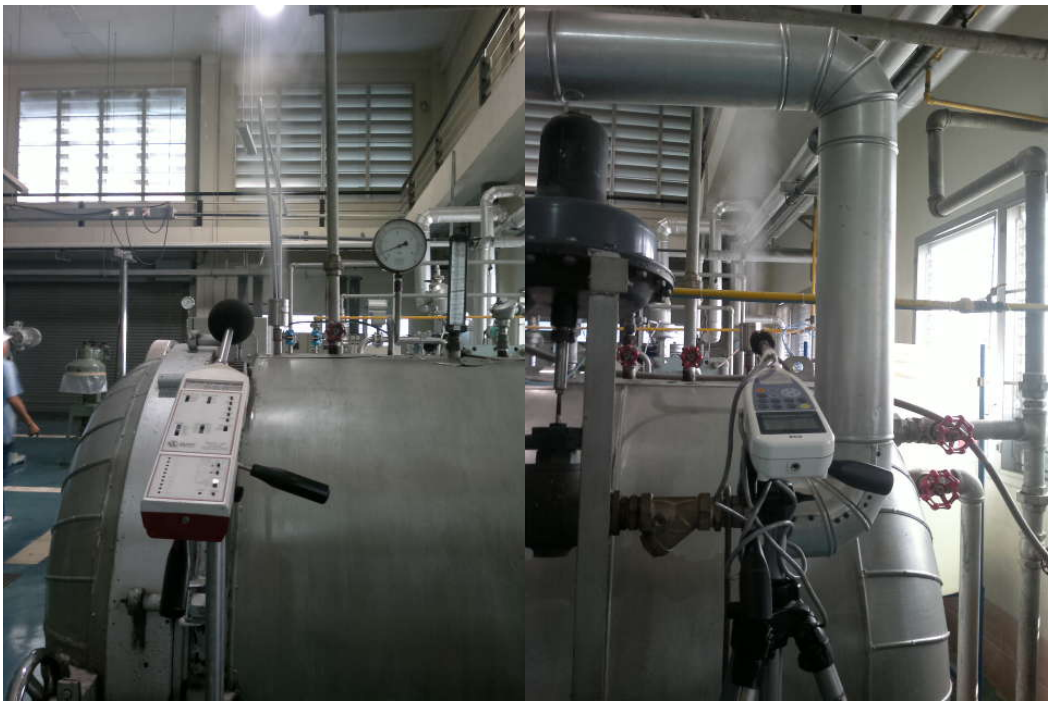

Figure A-8 The points of sound pressure level after install silencer for noise reduction testing from retort.

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