

## PRODUCTION PROCESS OF AN AUTOMOTIVE EXHAUST

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**Abstract:** *The main goal of this article is to illustrate all the steps needed to produce an automotive exhaust system. The exhaust system is of extreme importance to the vehicle, since it reduces the noise created by the ignition of the gases and improves the vehicle's performance. To better comprehend the product, all the components that compose the set were presented, their functions with tables and flowcharts. Moreover, the variables were essential to elaborate the process being presented the exhaust system, its functionality, its deterioration and the attention needed for this product. The article approaches the components that compose the set by breaking down the machines and process done to create the exhaust from raw material until shipping.*

**Keywords:** *automotive exhaust system, production process.*

### 1. INTRODUCTION

An automobile is composed of several assemblies and parts that are essential for the proper functioning of its system, quality and safety for the users. Among so many functionalities, this article highlights the system of exhaustion. Exhaust is of utmost importance to the vehicle, besides reducing noise level caused by the ignition of the gases, it also improves the performance of the vehicle, as much as the comfort of its customer avoiding harmful gases to reach the cabin, while also assisting in reducing fuel consumption.

The exhaust system is allied to the environment when maintenance is up to date, since the emission of toxic gases by automotive vehicles is a problem of every society, accounting for 40% of air pollution. This problem is gaining huge proportions as the growth of cars on the streets is increasing. The complete knowledge of the process of manufacturing an exhaust system is intended to bring further clarification about the subject. It is of utmost importance to know all the set components, the process each piece has to pass, applicability and importance of each item, being aware that the quality of the process depends on the good productivity of the devices.

The productive process of the exhaust system presented in this academic work aims to demonstrate the systemic importance of the process, so that it is necessary to have control of all the techniques employed in each production of item or sub item. It is worth noting the seriousness of knowing the quality of outsourced suppliers. All items are plausible to inspections, in order to ensure quality, health, safety and user comfort.

This article outlines the exhaust, its functionality, deterioration, cares for it, the necessary maintenance and the types of exhausts for each car, highlight the components that form the exhaust system the mufflers, the parts used to secure the vehicle exhaust system, as well as the machines and process to manufacture the product.

### 2. THE EXHAUST

The exhaust is responsible for conducting and treating harmful gases emitted by the engine, besides reducing the noise of the vehicle. Although not the most remembered when buying a car, it is very important for the proper functioning of the vehicle and for the preservation of the environment. It consists of three main parts, connected by the exhaust pipes, arranged between the engine and the vehicle's tailpipe.

The first part of the system is the collector. It is connected directly to the car engine and, to withstand the high temperatures to which it is subjected it is produced in cast iron or stainless steel. It consists of pipes that collect substances produced during the firing of fuel and direct them to the exhaust. In this part, the chemical reaction occurs and the gases become less harmful. As it passes through the catalyzer, the gases pass through the ceramic core, reacting with the existing noble metals.

The intermediate muffler consists of a set of pipes with holes and cameras that function as a resonance box. They reduce the noise produced by the engine. Thus, they reflect the high-frequency sound waves so that they partially cancel out. The noise reduction is ensured by the rear muffler located at the end of the exhaust, before the rear. It is responsible for capturing the most acute noises from a structure formed by some divisions. When gases travel from one muffler to another, noises and vibrations decrease due to the collision within the muffler. After all this process, the gases are thrown into the atmosphere by the rear in the least harmful way possible. That's why it is important to add the exhaust maintenance to the quality use of the car.

Given the poor quality of the gasoline in Brazil, the exhaust system has its life shortened. Among the parts of the exhaust system that most diminish the useful life, is the catalyzer, due to its function that is to transform the polluting gases less harmful. Nowadays, gasoline is full of impurities, adulteration and a higher alcohol concentration. The exhaust system can only survive up to three years. Therefore, it is a good idea to have a car check-up every six months or every twenty thousand kilometers. The toxic gas emitted by motor vehicles is the biggest source of pollution in big cities, being responsible for 40% of air pollution. The problem aggravates more with the increase in the number of cars.

## 2.1 Functions

The exhaust system has 3 main goals: to reduce the engine noise by absorbing sound waves resulted by the gases flows by a series of pipes and camera; control gases pressure by volume and flows for a better engine efficiency; and to conduct the gases out of the vehicle, avoiding a possible intoxication of the occupants of the vehicle.

## 2.2 Deterioration

The exhaust deterioration occurs because of corrosion, bad quality of gasoline, impacts on the bottom of the vehicle, engine malfunction. Exhaust system breaks occur due to speed bumps, lack of maintenance overloading the springs or incorrect installation. When there is a break in the support system such as: clamps and cushions, it is recommended to replace the broken piece since more pieces will lead to a bigger break. Exhaust leakage causes increased fuel consumption because of the change in the gases level, which can cause damage on the gear or ignition.

### 2.2.1 Care

Beware where to park the car, because the catalyzer can reach high temperatures, around 700°C and near papers or dry leaves can set them on fire. The counter pressure rate is specified by the automaker and is unique to the automobile model. Controlling and maintaining the counter pressure rate is fundamental to obtain higher engine efficiency. Before replacing some of the exhaust parts, analyze the set as a whole, because other parts can compromise the whole set along the time. Never weld the exhaust when one of the parts is broken because its internal components are already damaged and can't support the pipes and mufflers.

### 2.2.2 Maintenance

The correct maintenance of the exhaust prolongs the useful life of the engine, reduces the noise and aid the fight against pollution. The table of diagnose plan identify irregularities, possible causes and the correct procedures.

## 3. EXHAUST SYSTEM

### 3.1 Single Outlet Exhaust System

This is the most used exhaust tailpipe and is found in the majority of the cars. This exhaust tailpipe has one outlet for the out coming gases and is the cheapest to produce. However, this doesn't indicate it is the most efficient, though being very economic. The single outlet exhaust pipe is invariably at the rear of the vehicle usually on the driver's side.



**Figure 1. Single Outlet Exhaust System**

### 3.2 Opposed Dual Outlet Exhaust System

This exhaust pipe doesn't bend and functions differently. They circumvent the wheel and use the possibility of bending to add a filtering process. This type of system is very easy to find in vehicles that usually tow large loads. The dual outlet exhaust tailpipe is a variant of the rear dual exhaust system and is most effective under certain driving circumstances.



**Figure 3. Opposed Dual Outlet Exhaust System**

### 3.3 Side Double Exhaust System

The exhaust outlet is composed of two exhaust pipes that are side by side on the side of the car. The elimination of gases is more efficient and this makes the engine work better. Typically, the exhaust pipes are smaller than those that are used in the single exhaust so that the sound is more aggressive and deep. This type of system resembles high performance systems and offers many improvements in providing a car on the road.



**Figure 4. Side Double Exhaust System**

## 4. COMPONENTS

### 4.1 Pipes

#### 4.1.1 Primary Pipe

It is responsible for conducting the gases from the engine manifold to the catalytic converter. This part is produced in stainless steel so that it does not release fragments that can clog the catalyzer. Because it works at high temperature, it is difficult to wear off, once it does not house the water from the gases expelled by the engine. It does not retain water or oxidizing material, having a long service life.



**Figure 6. Primary Pipe**

#### 4.1.2 Flexible Pipe

Made of stainless steel, they are placed in the engine outlet tube to eliminate the rigidity of the exhaust system in the vehicle (the parts are not static, since they are only stuck in the brackets). The flexible pipe prevents premature breaking of the other parts that make up the system and also attenuates noise and vibrations.



**Figure 7. Flexible pipe**

#### 4.1.3 Catalyzer

The catalyzer is a part formed by a ceramic or metal core that transforms much of the toxic gases of the engine into harmless gases, through chemical reactions occurred within this component. It is located in the exhaust system, after the exhaust pipe of the engine, to better take advantage of the temperature resulting from the combustion. The catalyzer is plated with precious metals distributed among other chemicals, which are the activators of oxygen reactions that can dramatically reduce pollution without any type of filter in the catalyzer.



**Figure 8. Catalyzer**

#### 4.2 Mufflers

##### 4.2.1 Intermediate Muffler

By redirecting the gases inside, it reduces noises generated by the combustion of the gases in the engine and noise caused by the impact of gases with the environment. It also prevents the intake of gases in the cabin, improves the efficiency and therefore helps fuel economy, while eliminating or reducing the high frequency sound waves.



**Figure 9. Intermediate muffler**

##### 4.2.2 Rear Muffler

Completes muffler functions and reduces low frequency sound waves and gas elimination.



**Figure 10. Rear muffler**

## 4.3 TYPES OF MUFFLERS

### 4.3.1 Absorption Operation

While the flow of gases travels the muffler relatively unobstructed, sound waves penetrate through the perforations of the tube in the carcass filled with rock wool, where they are absorbed, by the higher frequencies, above 500 Hz.

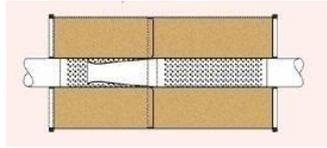


Figure 11. Absorption Operation

### 4.3.2 Reflection Operation

Gas streams and sound waves are redirected by open tubes and chambers in such a way that the sound waves, running back and forth, cancel out by interference. It is an effective solution, especially against tinnitus.

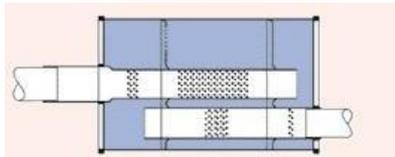


Figure 12. Reflection Operation

### 4.3.3 Mixed or Combined Operation

This item is characterized by the combination of the two principles mentioned above: absorption and reflection.

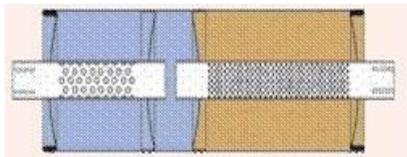


Figure 13. Mixed or Combined Operation

## 5. PRODUCT AND PROCESS DEVELOPMENT

The automotive exhaust is developed with tools of easy process insertion, by qualified operators, to guarantee total quality during the process.

### 5.1 Product Scope

The exhaust's main function is the elimination of gases, which are generated after the fuel is burned in the cylinders. That is, the basic purpose is to drive the resulting gases (pollutants), properly filtered to reduce pollution. However, this equipment has also the task to produce comfort, on reducing the engine noise determined by legislation, also, it avoids toxic gases from entering the interior of the automobile.

#### 5.1.1 Quality

For the production process a Quality Management System (QMS) was adopted, which was established to guarantee the quality of the services provided, to satisfy the customers' requirements by complying with the applicable legislation, norms and regulations. The Quality Management System is in compliance with the requirements of the International Standard ISO 9001: 2008. It was implemented as a quality control in a management that values this policy, always seeking to avoid damages to the environment and valuing employees.

### 5.1.2 Suppliers

In order to meet the requirements of the quality system implemented in this article, a program was developed to aim to qualify the suppliers. This program aims to assess fitness, competence and reliability and to re-evaluate them periodically. This way, a solid partnership is created between clients and suppliers, because a well done acquisition is a pre requirement for the quality of the final product. The Supplier Qualification Program (SQP) aims, primarily, identify, select, evaluate the performance, and stimulate the development to then, qualify or certify the supplier, using a frequently used conformity assessment tool for this stage of the audit program.

By using the SQP, the company can determine the technical capacities, the qualifications of the means, installation and organization of its suppliers. To guarantee the quality of the acquired products, it is of extreme importance the studies of process validation that decisively contributes to the reduction in the index of reanalyzes, reduction in the index of returns, to avoid the incidence of nonconformities and to diminish the incidence of nonconformities. The main objectives of the methodology of selection and qualification of the suppliers are:

- Focus on quality assurance;
- Concentration and improvement of negotiation capacity with suppliers;
- Control and prediction of response times;
- Reduction in costs;
- Follow-up activities.

**Table 1. Example of a supplier list**

<b>LIST OF QUALIFIED SUPPLIERS AND SUPPLIED PRODUCTS</b>				PREPARED:	Page: 1 of 2
				REVISIED:	REV:
QUALITY				APPROVED:	DATE:
SUPPLIER	PLACE	PLACE ORDER	SPECIFICATION/ NORM	SUPPLIED COMPONENTS	Register and data of Qualifications/ Acceptance and Auditing
GALVASUO	Renato Avenue, Monteiro, Porto Real, RJ, Brazil	01	The Specifications and Valid Norms are detailed in the Respective Lists of Product Parts	Galvanized Sheets	Qualified Report REL-GS-001
SIDERACO	Rua Sargento Silvio Hollerbach 405, Distrito Ind Botafogo, RJ, Brazil	02		Steel Pipes	Qualified Report REL-SD-012
METALIC	Rua Marcio Carvalho filho 1456, Distrito Queimados, RJ, Brazil	03		Steel Support Screw	Qualified Report REL-MT-008

### 5.1.3 Layout

The adoption of a „U“ layout aims to attend the following parameters:

- If there is the necessity of rework, this will be easier to return to the production line;
- The usage of materials and tools becomes easier and more efficient since the machines are set out in pre-determined locations;
- The group work is more valued since the work has to be done in harmony, respecting deadlines, time and cost.

### 5.2 Flowcharts

Flowcharts illustrate the global process while indicating which production step the product is. While working together with the „U“ layout, there is limited stock favoring the inspection inside the workplace, being done by the own collaborator, this way, the quality of the process will be assured since the evaluation of the final product will be guaranteed throughout the other steps. With the elaboration of the flowcharts, the degree in knowledge of the process is increased adding more information to the systemic process.

### 5.3 Items Produced

Conductive pipes are made of galvanized steel with a thickness of 1.5 mm to conduct the gases to the dampers and to the atmosphere.

Dampers can be divided in two parts: intermediate and rear. The intermediate works stationary after the catalytic converter and before the rear damper. Its function is to reduce noise and increase the engine's performance. The rear damper completes the function of the intermediate muffler, by reducing the sound waves of the high frequencies.

## 6. MACHINES

### 6.1 Mig Welding Machine

The mig machine is responsible for making the manual welds, though being limited to low/medium productivity, because it depends on the operator to execute the welds. However, it welds well with an arch stable for industrial applications.



Figure 14. Mig Welding Machine

### 6.2 Bending Machines

#### 6.2.1 Pipe Bending Machine

This machine is responsible to fold the pipes in the specific measurements in the three axes (X, Y and Z). It is a motorized hydraulic machine to bend thin or thick wall pipes within the 3 main axes "X", "Y" and "Z", electronically monitored and axes of hydraulic and electric drives. It has a reinforced structure made of laminated steel sheets welded together with machined table surface, with linear guides and ball bearings, lower housing for turning mechanism (Hydraulic), hydraulic drive unit with proportional pressure and flow valves And hydraulic blocks, electrical panel positioned on the back of the same



Figure 15. Pipe Bending Machine.

#### 6.2.2 Press Break

The folding press machine is responsible for cutting, folding in different shapes due to its tools (table and matrix) during the process of fabricating the item. It is built with solid weld, which includes annealing to free pressure, which minimizes deflection. The press has professional system control name Cybele or Delem.



**Figure 16. Press Break**

### 6.3 Cutting

#### 6.3.1 Poly Cut Machine

Poly cut is a machine responsible to cut the pipes and plates in specific measurements, making the cuts with angles when necessary and with a great finish in the cut area.



**Figure 17. Poly cut machine**

#### 6.3.2 Multiple Holder Machine

This machine is Machine responsible for piercing the inner tubes of the muffler. Equipment with high operating performance, as it can perform several simultaneous holes with the same or different measures of the drills.



**Figure 18. Multiple holder machine**

#### 6.3.3 Scrap Plate Scissor

Machine responsible for cutting materials in the respective measurements, equipment used in the preparation sector, performs cuts on all the plates involved in the exhaust manufacturing process. Applying cuts on the blanks preparing for entry into the presses.



Figure 19. Scrap Plate Scissor

## 7. PROCESS

Receipt is responsible for receiving and releasing the raw materials for the productive sector;

Preparation cuts the plates and pipes in the required dimensions;

Folding machine is the sector responsible for folding the pipes, through appropriate equipment and with adequate capacity. For this sector only pipes are to be folded, according to specifications of bend radius size and pipe diameter;

Poly cut is the area where parts are cut in dimensions and size, according to specifications;

Stapling is the sector responsible for the closure of the central, intermediate and lateral silencer body. The process is carried out through the equipment able to join the ends of the plate, closing in a way that does not leak the gases or noise, thus isolating it so that it does not cause noise or respiratory pollution due to gases;

Circular Welding is responsible for welding the components (pipes), in a circular and uniform way with appropriate and automatic equipment;

Inspection is responsible for carrying out product approval or failure and releases the parts to the packaging sector;

Packaging is responsible for packaging the product so that it is not damaged upon reaching the customer;

Shipment is responsible for sending the buyers or recipients the goods purchased. This sector operates in close liaison with the others, among them: warehouse, the purchasing sector, inventory controllers, etc., all interacting and under the supervision of the commercial department of the company.

## 8. CONCLUSION

The article had as main objective to present the importance of a vehicle exhaust system, its set of pieces, which often goes unnoticed in the eyes of the drivers, but which needs carefulness and attention redoubled

Nowadays, exhaust is considered a great villain of nature, where 40% of air pollution is caused by the emission of gases through the exhaust, which is often in need of maintenance or exchangeable. This problem worsens daily, in Brazil there are more than 20 million vehicles transiting cities, only in São Paulo there are more than 4.5 million vehicles. The lack of vehicle information and knowledge can be considered two major factors that are responsible for these environmental problems.

The lack of maintenance is also a major problem, not only for the environment, but for the health and safety of drivers and passengers, where it can endanger the physical integrity of all the components of the car and also those that are nearby in the street. In addition to that, the lack of maintenance can cause fines to the driver for noncompliance with the regulatory rules, Conama.

Besides these items that were emphasized in the article, it was highlighted the importance of knowledge in the productive process of an exhaust and the basic notion on the part of the drivers of the best type of exhaust for their car, since often the set is exchangeable and there are several models available on the market.

The correct functioning of the exhaust system depends on the driver alone, who must always be aware of noises and odors, because only in this way will it be possible to preserve the environment, avoid infractions and avoid serious and even fatal accidents

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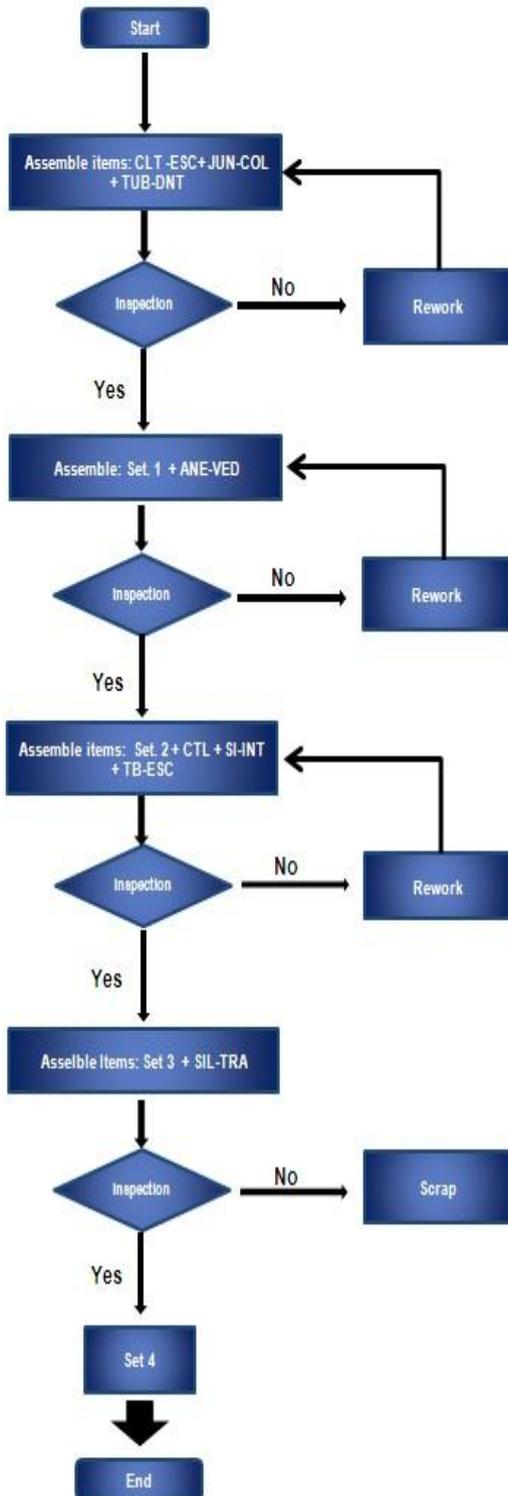
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## 10. RESPONSIBILITY NOTICE

All the authors: Adrieli, Alison, Maria, Mariane, Tatiane and Thalison acknowledge that the article is original, is not under consideration by another journal, has not previously been published elsewhere and its content has not been anticipated by any previous publication.

Fig A.1. Flowchart



Pieces	Description	Acronym	Start / End
1	Exhaust Intake / manifold	CLT-ESC	Set. 1
2	Collector set	JUN-COL	
3	Front pipe	TUB-DNT	Set. 2
4	Sealing ring	ANE-VED	Set. 3
5	Catalyzer	CTL	
6	Intermediate muffler	SI-INT	Set. 4
7	Clamp	TB-ESC	
8	Rear muffler	SIL-TRA	

Fig A.2. FMEA

METHOD ANALYSIS AND EFFECT OF POTENTIAL FAILURE								
FMEA Num: 1		Start Date: 09-03-2016			Responsible: Alison			
Area: Assembling		Revision: 01			Done by: Alison/Talison			
System: Channel gaseases and soundwaves		Group: Adrieli/ Mariane/ Maria Aparecida/ Talison/ Tatiane						
COMPONENT NAME	COMPONENT FUNCTION	FAILURE METHOD(S)	EFFECT(S) OF POTENTIAL FAILURE(S)	OCCURENCY (TAB) 1	SEVERITY (TAB) 2	DETECTION (TAB) 3	RISK (RPN) (O)*(S)*(D)	RECOMMENDED CORRECTIVE ACTION
Engine pipe	Collect the expelled gases, conducting them to the catalyzer	diameter out of specification	ineficiency to collect gases	1	7	3	21	check tool after every production
Lambda probe or oxygen sensor	Device that sends an electronic injection sign indicating that oxygen in the exhaust gas	defected senson	failed to read fuel-air	2	3	5	30	Require supplier to perform documented tests
Flexible Pipe	Prevent the transmission of vibratio	nipped flexible pipe	vibrations from the engine causing system breakdown	4	3	1	12	To analyze siphon flexibility
Catalyzer	To filter gases from the engine by turning them from noxious gases to inert gases	misplaced ceramic kettle	does not filter the gases, releasing them to the atmosphere	5	8	2	80	Properly install the ceramic kernel
		crack in the weld	crack increases until the exhaust breaks and falls off	5	8	8	320	Instruct them through training on the importance of a well-done weld
Intermediate Set	Central part of the system, which makes the primary / silent set	lack of ideal grip on the bolts	vibrations, causing noise underneath the vehicle	3	3	2	18	Check bolt tightening, and perform vibration testing on the system
Rear Set	Main part of the system / Higher volume / eliminate sound waves Of low frequency by completing the	oxidation of the set	holes can occur and with oxidation ineffective the muffling of sound waves	3	2	2	12	To analyze raw material of greater durability and lower price / And guide clients on the Best way to preserve the system

Fig. A.3. LIST OF PARTS AND COMPONENTS

LIST OF PARTS AND COMPONENTS							N: 138/16
EXHAUST SET - CSF 001 - 1000							PAGE: 2/3
							REV.0
-	3	1	JFT-001-11	1	FLANGE	-	DES 03825-11 REV. A
-	4		MOD 0315/03.2		STEEL SHEET	LAMINATED STEEL SHEET 3/4"	-
-	3	1	TBC-001-24	2	STEEL PIPE	STEEL PIPE WITH SEWING 27X1.50	DES 03825-24 REV. A
-	3	1	CST-001-21	3	MUFFLER BODY	-	DES 03825-21 REV. A
-	4	1	MOD 0315/03.5	-	GALVANIZED SHEET	LAMINATED STEEL SHEET 0.7MM	-
-	4	3	TBC-001-20	4	INTERNAL PIPE OF HOLE WALL	STEEL PIPE WITH SEWING 27X1.50	DES 03825-20 REV. A
-	4	2	APC-001-23	5	SUPPORT TRAIL	-	DES 03825-23 REV. A
-	4	1	TCL-001-22	6	LEFT MUFFLER SIDE COVER	-	DES 03825-22 REV. A
-	4	1	TCL-001-22	7	RIGHT MUFFLER SIDE COVER	-	DES 03825-22 REV. A
-	3	1	MOD 0315/03.10	8	STEEL PIPE	STEEL PIPE WITH SEWING 27X1.50	-
-	3	2	MOD 0315/03.11	9	HOLDER	-	-
5	2	-	PFM.001-400		REAR MUFFLER	-	DES 03825-400 REV. A
-	3	1	MOD 0315/04.1	1	STEEL PIPE	STEEL PIPE WITH SEWING 27X1.50	-
-	3	1	CTS-001-21	2	MUFFLER BODY	-	DES 03825-21 REV. A
-	4	1	MOD 0315/04.3	-	GALVANIZED SHEET	LAMINATED STEEL SHEET 0.7MM	-

Fig. A.4. LAYOUT

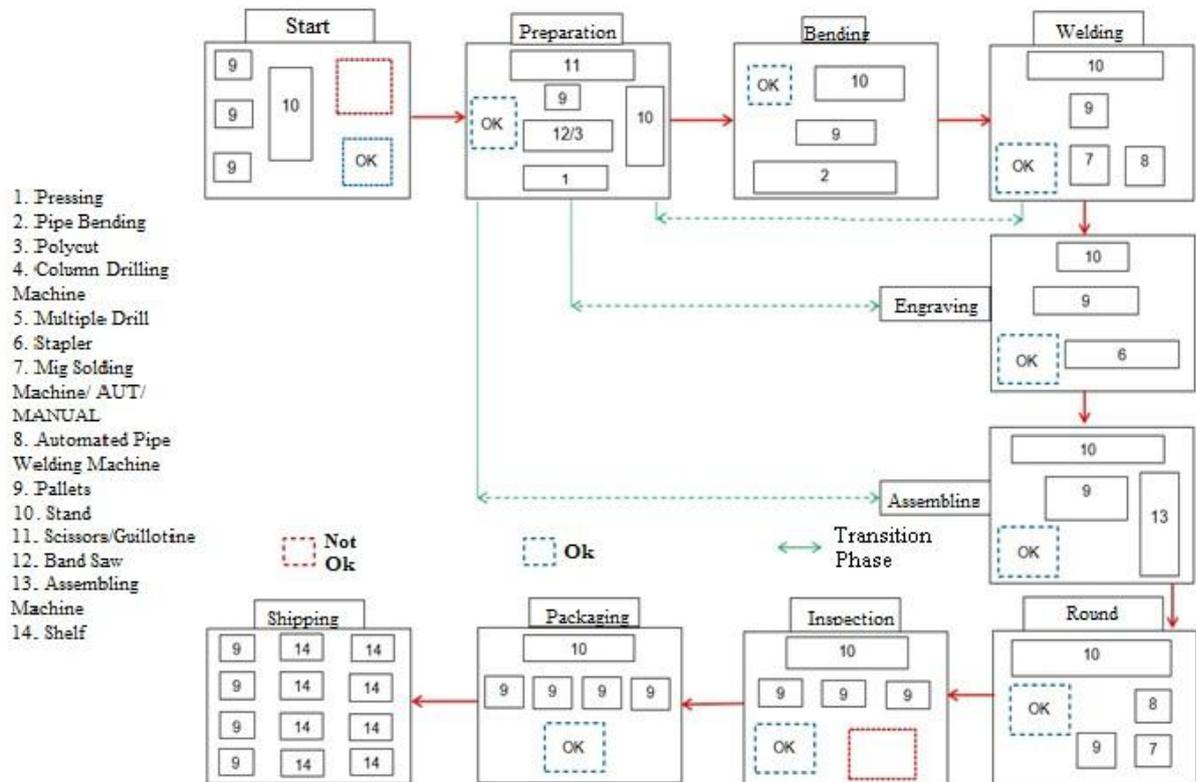


Fig. A.5. CONAMA RESOLUTION

The NATIONAL ENVIRONMENT COUNCIL – CONAMA, in the use of the power bestowed upon the Council by Laws 6.938 from Aug. 31, 1981, 8.028, from April 12, 1990, 8.490 from November 19, 1992, Decree 99.274 from June 6, 1990 and in light of its Internal Regulations, and Considering that excessive noise is hazardous to physical and mental health and has a particular effect on hearing;

Considering the need to reduce Sound pollution within urban centers;

Considering that roadway motor vehicles are the main environmental noise sources;

Considering that the use of known adequate technologies allows for the control of sound pollution;

Considering the objectives of the National Program for Education and Control of Sound Pollution “SILÊNCIO”, decides:

Art. 1 To establish maximum noise limits for national and imported vehicles, except motorcycles, scooters, tricycles, mopeds and bicycles with auxiliary engines and similar vehicles, both while running but still and during acceleration.

§ 1 The noise limits for nationally produced vehicles for national market purposes will enter into effect for accelerating vehicles according to the below schedule and brand, as defined by table 1 of this Resolution:

a) Cycle Otto motor vehicles except for those in the <<c>> and <<d>> categories;

a.1) a minimum of 20% of all produced vehicles from March. 1st 1994;;

a.2) a minimum of 50% of all vehicles produced from Jan. 1st, 1995

a.3) 100 % of all produced vehicles from Jan. 1st, 1997;

b) all Diesel motor vehicles and auto motor vehicles possessing Otto cycle engines of “c” and “d” categories:

b.1) minimum of 40% for vehicles produced from Jan. 1st, 1996;

b.2) 100% of cycle OTTO engines produced from Jan. 1st, 1997;

b.3) 100% of all vehicles produced from Jan. 1st, 1998 .

Table A.1. Maximum noise limits for acceleration vehicles, according to NBR-8433

Category'		Noise Level / Level dB(A)			
Description		Otto	Diesel		
			Direct Injection	Indirect Injection	
A	Passenger cars of up to nine places and mixed-use vehicle derived from a car	77	78	77	
B	Passenger vehicle with more than nine seats, cargo or traction vehicle mixed purpose vehicle not derived from a car	PTB up to 2.000 kg	78	79	78
		PTB above 2000 kg and up to 3.500 kg	79	80	79
C	Passenger or mixed use vehicle with PTB greater than 3500 kg	Maximum power below 150 kW (204 CV)	80	80	80
		Maximum power equal or above 150 kW (204 CV)	83	83	83
D	Cargo vehicle or with a PTB traction above 3.500 kg	Maximum power below 75kW (102 CV)	81	81	81
		Maximum power between 75 and 150 kW (102 to 204 CV)	83	83	83
		Maximum power equal or above 150 kW (204 CV)	84	84	84