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Noise Level of Factory Area Department IB PT Petrokimia Gresik Using Noise Mapping Method and Niosh

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Abstract
Noise is a problem in the industrial sector, this resulted in many cases of hearing loss due to noise in industrial areas. PT Petrokimia Gresik has implemented noise control and started implementing several elements/components of the Hearing Conservation Program (HCP)/Hearing Conservation Program (PKP) to control noise. However, the PKP special program has not been implemented systematically, only a few elements/components have been implemented. The research objective was to determine the mapping and noise level in the factory area in the IB department of PT Petrokimia Gresik using the Noise Mapping and Niosh methods. Based on the results of measurements in the field, there are 11 highest noise points which are above the noise level quality standard of Regulation Number Per.13/Men/X/2011 before control is carried out. The highest noise point is 106 dB at point 10. Based on noise level measurements, the length of exposure recommended by NIOSH varies, and depends on the measurement results obtained the longest exposure time allowed at point 10 is 34.2 minutes. This measurement point is closest to the noise source, so workers are required to use PPE in the form of ear plugs, ear muffs and safety hats. The PPE can reduce the amount of acoustic energy on the hearing mechanism of workers at PT Petrokimia Gresik.
Keywords: *noise, factory area, noise mapping, niosh*

Abstrak
Kebisingan merupakan salah satu masalah di sektor industri, hal ini mengakibatkan banyaknya kasus gangguan pendengaran akibat kebisingan di kawasan industri. PT Petrokimia Gresik telah menerapkan pengendalian kebisingan dan mulai menerapkan beberapa elemen/komponen *Hearing Conservation Program* (HCP)/Program Konservasi Pendengaran (PKP) untuk mengendalikan kebisingan. Namun, program khusus PKP belum dilaksanakan secara sistematis, hanya beberapa elemen/komponen saja yang telah dilaksanakan. Tujuan penelitian ini adalah untuk mengetahui pemetaan dan tingkat kebisingan di area pabrik pada departemen IB PT Petrokimia Gresik dengan menggunakan metode *Noise Mapping* dan *Niosh*. Berdasarkan hasil pengukuran di lapangan, terdapat 11 titik kebisingan tertinggi yang berada di atas baku mutu tingkat kebisingan Permenaker No. Per.13/Men/X/2011 sebelum dilakukan pengendalian. Titik kebisingan tertinggi sebesar 106 dB berada di titik 10. Berdasarkan pengukuran tingkat kebisingan, lama pemaparan yang direkomendasikan oleh Niosh berbeda-beda, dan tergantung dari hasil pengukuran yang diperoleh Waktu pemaparan terlama yang diperbolehkan pada titik 10 adalah 34,2 menit. Titik pengukuran ini paling dekat dengan sumber bising, sehingga pekerja diwajibkan menggunakan APD berupa ear plug, ear muff, dan topi pengaman. APD tersebut dapat mengurangi besarnya energi akustik pada mekanisme pendengaran pekerja di PT Petrokimia Gresik.
Kata Kunci: *kebisingan, area pabrik, noise mapping, niosh*

1. Introduction

The industrial sector is one of the primary sources of noise pollution, surpassing various other sources. Consequently, noise-induced hearing loss incidents have been reported in numerous industrial regions.[1],[2]. Indonesia, as a developing nation, relies heavily on industrial equipment to facilitate work processes, with labor being a major component in managing raw materials, machinery, equipment, and other necessary processes that produce beneficial products for society. However, the use of machines and tools in the industry generates sound intensity that can result in noisy working environments, leading to negative health consequences.[3],[4]. Around us, there are various sources of noise, such as industrial noise (from factories), airports, highways, and entertainment venues. Some occupations consistently face noise, including mining, tunneling, excavation (blasting, drilling), work that utilizes heavy machinery (such as printing, iron forging proses, textile machines, and paper machines), and jobs that involve driving machines with powerful combustion (such as trucks, construction vehicles, or engine trials).

Noise is a persistent problem in the workplace and can pose a serious health threat to workers, potentially causing mild to severe and even permanent hearing loss. Addressing this issue has been challenging in the past, as noise is a factor that cannot be easily eliminated from the work environment [5]. Noise-induced hearing loss can occur suddenly or slowly over months to years. The sufferer often does not realize it, so by the time they complain of hearing loss, it is usually in an irreversible stage [6],[7]. In general, noise is a stressor that affects hearing (an auditory stressor) and can cause health disturbances either directly (auditory effects) or indirectly (non-auditory effects) [8].

PT Petrokimia Gresik is a major industry in Indonesia and a subsidiary of State-Owned Enterprises (BUMN) under Pupuk Indonesia Holding Company (PIHC). The company specializes in the production of fertilizers and chemicals, as well as offering construction and engineering services. As the leading manufacturer of fertilizers, PT Petrokimia Gresik operates three factories (Factory I, Factory II, and Factory III) and a port with sufficient production capacity to meet consumer demand. However, the production process poses a risk of noise pollution due to the machinery used and work processes carried out. This risk could lead to workers suffering from hearing loss if the noise level exceeds the predetermined threshold value (NAB). One of the factories at PT Petrokimia Gresik with significant noise levels is Factory I, which consists of four work units: the Ammonia Plant Unit, Urea Plant Unit, ZA Plant Unit I & III, and Utility Unit I. Based on the researcher's initial survey, factory IB PT Petrokimia Gresik exhibits the highest average noise levels. Specifically, the Ammonia Plant Unit has the highest noise intensity, measuring 106 dB (A) on the upper floor and 85 dB (A) on the lower floor. Noise intensity in this area is constant and steady, with a broad frequency range. As per the noise level readings, workers can operate for eight hours per day, split into three work shifts.[9].

In Aryo Sasmita's research on grid-based noise cancellation with 178 cancellation points and the calculation of exposure time with the NIOSH equation. The result of the research shows that the lowest noise level is 53 dB and the highest is 91.1 dB. There are 27 points that exceed the threshold value of noise level of 85 dB. The noise exposure time applied to point 73, as the highest noise point, is only 117 minutes. From the noise exposure, it is learnt that the noise level distribution pattern is used as the basis for noise control measures [10]. Based on the description above, the researcher is interested to do a research with the title "Machine Noise Level Analysis and Noise Level Mapping of Department 1B Factory Area of PT Petrokimia Gresik using Noise Mapping and Noish methods". The advantage of these two methods is that it can determine the location of the noise area and can determine the maximum durability limit of the hearing duration of workers in the noise area.

2. Material and Methods

In the research process, researchers used the Noise Mapping and Niosh methods. Noise Mapping is a noise mapping that describes the pattern of noise levels in an area [11]. In the industrial field, noise mapping is usually used to predict noise distribution patterns around the factory, which aims to design measures to control and reduce the spread of noise and thus meet applicable noise laws [12]. The purpose of this research is to measure the noise level generated by the production machine at the research location. Mapping the noise level with the surfer 13 program. Analyzing the comparison of the noise level that occurs at the research location with the noise level quality standard of the Regulation of the Minister of Manpower and Transmigration of the Republic of Indonesia Number 13 of 2011. Calculating the maximum time of exposure to the noise level generated based on the NIOSH calculation method [8].

Meanwhile, Niosh plays an important role in identifying risks and noise in the workplace, as well as developing guidelines to protect workers from noise hazards. The purpose of conducting research is to be able to find out the location of the noise area and be able to find out the maximum resistance limit for the duration of workers' hearing in the noise area. The first step is to collect the data used in the research.

Data Collection

The research data collection was carried out by surveying and taking noise samples directly using a Sound Level Meter tool in the Department 1B ammonia production area of PT Petrokimia Gresik.

Primary Data Collection consists of:

a) Documentation, which is an observation method by documenting the research process. This documentation is a photo when measuring the noise level on the research object using a Sound Level Meter.
b) Literature study, namely by reviewing literature in the form of books, previous reports, research, and relevant journals.
c) Direct measurement of noise levels, which is to obtain primary data on noise levels.

As for the collection of secondary data in this study, namely the layout of PT Petrokimia Gresik.

After collecting all the necessary data, it is necessary to measure the noise to determine the noise level using the specified formula.

Noise Measurement Method

Calculation and data processing using the Niosh calculation formula, which controls the noise aspect based on the noise distribution map in the production area. So that the calculation and evaluation of the environmental noise level [5].

The selection of noise measurement methods is carried out in accordance with the provisions of Decree of the Minister of Environment No. 48 of 1996, Annex II on measurement methods and SNI 7231-2009 in the form of determination of noise level standards.

Mapping and determination of noise area at PT Petrokimia Gresik as many as 11 measurement points. The tool used for noise measurement is a sound level meter. One day of noise sampling represents seven days of measurement. This is due to the condition of tools and machines that live or operate for 24 hours, so it is assumed that the condition of the machine is always the same.

Each measurement must be able to represent a certain time interval in 1 work shift with the following determination [5]:

1. L1 taken at 08:00 representing 07:45 - 10:00 am
2. L2 is taken at 11:00 which represents 10:00 – 02:00 pm
3. L3 taken at 15.00 representing 14.00 - 05.00 pm

The calculation of the length of time workers are exposed to noise is done using the method (Niosh, 1998). Using the following equation:

Leq calculation using the formula (KepMenLH,1996:(pers 1)

$$Leq = 10 \text{ Log } [\frac{1}{N} \times (\Sigma\ ni\ \times 10^{0,1 \times Li})] \text{ dB}$$

$$T = \frac{480}{2^{(L-85)/3}}$$

Description :

T = maximum allowable exposure time at that point (minutes).

L = noise level at that point.

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3. Result and Discussion

PT Petrokimia Gresik is an Indonesian company that specializes in providing complete fertilizer services, including ammonia production. The IB department of PT Petrokimia operates 11 main machines, and their noise levels need to be identified. Please refer to Table 1 for a comprehensive list of noise sources within the IB department of PT Petrokimia Gresik.

Table 1. Identification of Noise Source in the IB Department of PT Petrokimia Gresik.

No	Location	Noise Source
1	Point1	Filter Gas
2	Point 2	Natural Gas
3	Point 3	Desulfurizer
4	Point 4	Primary Reformer
5	Point 5	Secondary Reformer
6	Point 6	Purifier
7	Point 7	Syngas Compressor
8	Point 8	Amonia Conventer Effluent Cooler / BFW (Boiled Feed Water) Preheater
9	Point 9	Methanor
10	Point 10	HTS (Hight Temperature Shift) Converter
11	Point 11	LTS (Low Temperature Shift) Converter

Source: PT Petrokimia Gresik

To determine the locations of the 11 machines' noise source points, a map of the noise source area was created as shown in **Figure 1.** This will simplify the process for workers and identify the machines/points responsible for generating noise. According to noise measurements taken in the production area, **Figure 2** documents machine noise measurements conducted with SLM. It is evident that the work process of the production machines used at PT Petrokimia Gresik is the source of the noise.

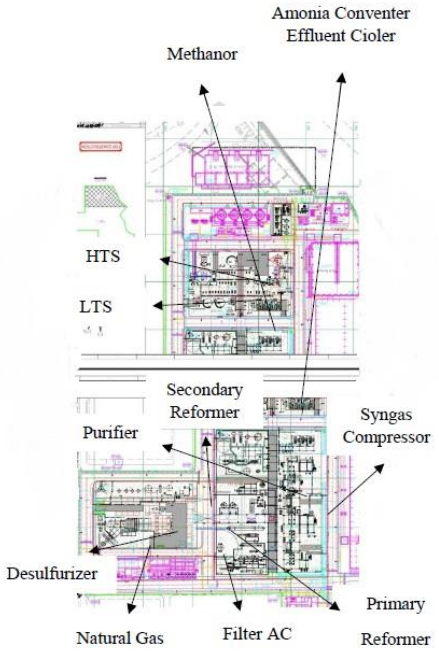

Figure 1. Noise Distribution Mapping of IB Department of PT Petrokimia Gresik (Source PT Petrokimia Gresik)
Source: PT Petrokimia Gresik

Figure 2. Research Documentation

Noise data collection is conducted during normal operational conditions with no other activities impacting the noise level such as heavy rain, hurricanes, or work accidents. Abbreviated terminologies are explained upon first usage. The noise data presented in **Table 2** represents noise measurements taken at point 1, with measurements taken every 5 seconds for 10 minutes, resulting in 120 data points for each measurement location.

Table 2. Noise Measurement Data of Point One (AC Filter Area) at 07.45WIB Every 5 Seconds for 10 Minutes

Noise Level dBA				
0-2 Minutes	2-4 Minutes	4-6 Minutes	6-8 Minutes	8-10 Minutes
94,5	94,7	94,2	94	94,3
94,1	94,6	94,8	94,5	94,2
94	94,3	94,1	95,2	94,8
95,3	94	94,9	95,1	94,7
94,1	94,7	95,6	94,9	95,2

Noise Level dBA				
0-2 Minutes	2-4 Minutes	4-6 Minutes	6-8 Minutes	8-10 Minutes
94	94,8	94,1	95,1	94,5
94,2	95,3	95,2	94,7	94
94,9	94	94,6	95,3	94,2
95,2	95	94,5	94,1	95,2
95,5	94,7	94,1	94,3	95,4
94	94,1	94,3	94,9	94,6
95,3	94,9	95	95,2	94,1
94,1	94,5	94,9	94,7	94,7
94,3	94,6	95,3	95,2	94,8
94,6	94,6	94,8	95,1	94,6
94,9	94,7	95	94,9	95,1
95	95,7	94,2	94,5	95
94,8	94,6	94,5	94,4	94,7
94,7	94,1	94,6	95	95
94,5	94,4	94,7	94,1	94,2
94,3	95,1	94,1	95,3	94
94,3	95,2	94,5	94,8	94,6
94,7	94,2	95,1	94,2	95
95,3	95,1	94,7	94,9	94,5

The red coloured numbers are the highest and lowest measurement results at point 1.

Noise measurements were conducted on Tuesday, March 21, 2023, between 07:45 and 09:53 WIB at 11 measurement points in Department 1B of PT Petrokimia Gresik, using a sound level meter (SLM) tool.

The obtained data was calculated using a predetermined formula. The results indicate that the highest noise level was 95.7 dB, while the lowest was 94 dB. Based on the maximum and minimum values in the table, determine the values of r (range), k (number of classes), and i (class interval) to establish the frequency distribution.

Value r

r = Max–Min

=95,7 – 94

=1.7

Value k

k =1 +3,3 Log n

=1 +3,3 Log 120

=7,86

Value i

$\frac{r}{k}$ i =

=1,7/7,86 =0,2

Afterwards, the Leq is computed. The Leq is the equivalent continuous noise level, representing a particular noise value over a specified time interval. **Table 3** presents the results of frequency calculation, based on the noise interval, center value, and frequency of interval.

Table 3. Frequency Distribution of Point One (AC Filter Area)

Noise Interval	Centre Value	Frequency
94 - 94,2	92,1	28
94,3 - 94,5	94,4	19
94,6 - 94,8	94,7	30
94,9 - 95,1	95	24
95,2 - 95,4	95,3	16
95,5 - 95,7	95,6	3

From the frequency distribution data above, the Leq value is then calculated.

Leq Value

$$Leq = 10 \text{ Log } [\frac{1}{N} \times (\Sigma\ Tn \times 10^{0,1 \times Ln})] \text{ dBA}$$

$$Leq = 10 \text{ Log } [\frac{1}{120} \times (28 \times 10^{0,1 \times 94.1}) + (19 \times 10^{0,1 \times 94,4}) + (30 \times 10^{0,1 \times 94,7}) + (24 \times 10^{0,1 \times 95}) + (16^{0,1 \times 95,3}) + (3 \times 10^{0,1 \times 95.6})] \text{ dBA}$$

$$= 94,69 \text{ dBA}$$

According to the calculation provided, the Leq value for L1 at point one is 94.69 dBA using the Leq formula for point one (AC Filter Area). The same calculation has been performed at ten other points (Natural Gas Area, Desulfurizer, Primary Reformer, Secondary Reformer, Purifier, Syngas Compressor, Ammonia Converter Effluent Cooler/BFW Preheater, Methanor, HTS, LTS), resulting in noise level data being obtained at eleven points in the PT Petrokimia Gresik work area, demonstrating in **Table 4.**

Table 4. Results of Noise Level Evaluation

Noise Source	Noise dBA	Description
Filter Gas	94,69 dBA	Above threshold value (NAB)
Natural Gas	100 dBA	Above threshold value (NAB)
Desulfurizer	89.57 dBA	Above threshold value (NAB)
Primary Reformer	85 dBA	Limit threshold value (NAB)
Secondary Reformer	92.81 dBA	Above threshold value (NAB)
Purifier	91.13 dBA	Above threshold value (NAB)
Syngas Compressor	93.19 dBA	Above threshold value (NAB)
Amonia Conventer Effluent Cooler / BFW (Boiled Feed Water) Preheater	89.45 dBA	Above threshold value (NAB)
Methanor	99.32 dBA	Above threshold value (NAB)
HTS (Hight Temperature Shift) Converter	106.21 dBA	Above threshold value (NAB)
LTS (Low Temperature Shift) Converter	99.36 dBA	Above threshold value (NAB)

Furthermore, after obtaining the noise results, a noise contour map is made to determine the area of the machine that has the lowest to highest noise contour.

3.1 Noise Contour Mapping Using Noise Mapping Method

Depicting the relative location of all noise sampling points, this sketch includes the noise level data surrounding each sampling point [13]. Noise mapping is created by inputting the Leq data that has been calculated using *Golden Surfer software*. The noise level is indicated by the color on the mapping; the redder the color, the higher the noise level.

From the results of noise measurements, *Surfer Software* is utilized to process data. The necessary data includes coordinate points (x and y) and the average noise level data (z). The Surfer worksheet is populated with coordinate and average noise level data, which is then presented as contour maps. Technical abbreviations are explained upon first use.

Contour map is a map that describes some of the natural shape of the earth's surface by using contour lines [14]. This relative relief information is shown by drawing contour lines densely for steep areas, while for sloping areas it can be shown by drawing the lines loosely [15]. This contour can provide relief information, either relatively, or absolutely [14]. The noise level distribution pattern is grouped in **Table 5** and **Figure 3** contour map on the following noise distribution.

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Table 5. Pattern of Noise Level Distribution

Distribution Pattern	Noise Level
Hijau	74 dB – 85 dB
Kuning	86 dB – 92 dB
Orange	92 dB – 94 dB
Kuning	85 dB – 90 dB
Merah Muda	96 dB – 104 dB
Merah	> 106 dB

The following is a map of the noise level pattern at the study site.

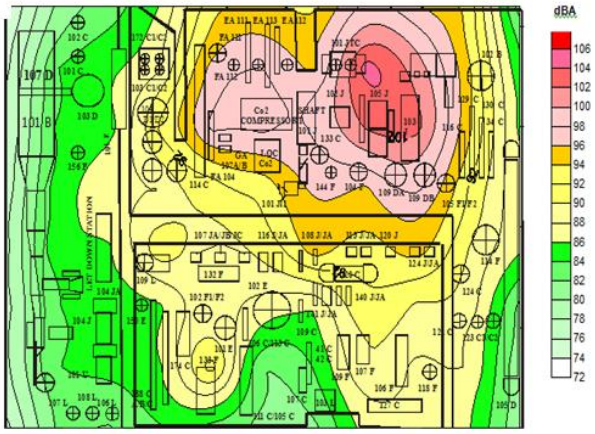

Figure 3. Noise Contour Map of Production Department I PT Petrokimia Gresik (software suffer)

After acquiring the distribution pattern of the noise contour map, the Niosh formula is utilized to calculate the endurance limit of workers within the noisy area.

3.2 Calculation of Exposure Time Using Niosh

Based on the mapping of noise levels in the production area, we calculate measurements at designated points grouped according to the intensity of the noise levels exceeding the quality standard threshold (>85 dB) and the intensity of the noise levels not exceeding the quality standard threshold (<85 dB), in accordance with the guidelines outlined in the Minister of Labor Regulation No. 13 of 2011. The NIOSH method is employed to determine the duration of time during which workers can be exposed to the noise.

NIOSH calculation indicates that the noise level should not exceed the quality standard threshold (<85 dB), specifically at point 4 where the noise level is 85 dB(A) :

$$T = 2^{\frac{480}{(L-85)/3}}$$

$$= \frac{480}{2(85-85)/3} = 480 \text{ Minutes} = 8 \text{ hours}$$

While point 10 exceeds the highest quality standard threshold (>85 dB) with a noise level of 106.21 dB(A) :

$$T = \frac{480}{2^{(L-85)/3}}$$

$$= \frac{480}{2(106.21-85)/3} = 3{,}57 \text{ Minutes} = 0{,}05 \text{ hours}$$

From the calculation results at point 10, it is determined that workers may be exposed to noise consecutively for a maximum of 3.57 minutes or .05 hours. Point 10, being located very close to the operating machine, exhibits the highest noise level and exceeds the quality standard, resulting in a reduced allowed exposure time of less than 8 working hours.

Table 6 shows the length of time workers can receive noise exposure at the eleven points. At these points further handling is needed, so as not to cause occupational diseases, especially the risk of damage or hearing loss caused by time exposed to noise that exceeds the standard.

Table 6. Exposure Time of Eleven Points Based on Niosh Method Calculation

Noise Source	Duration of Exposure (Minutes)	Duration of Exposure (Hours)	Desscription
Filter Gas	51,15	0,85	Above threshold value (NAB)
Natural Gas	15	0,25	Above threshold value (NAB)
Desulfurizer	166,98	2,78	Above threshold value (NAB)
Primary Reformer	480	8	Limit threshold value (NAB)
Secondary Reformer	78,98	1,31	Above threshold value (NAB)
Purifier	116,44	1,94	Above threshold value (NAB)
Syngas Compressor	72,34	1,20	Above threshold value (NAB)
Amonia Conventer	171,55	2,86	Above threshold value (NAB)
Effluent Cooler / BFW (Boiled Feed Water) Preheater			
Methanor	17,55	0,29	Above threshold value (NAB)
HTS (Hight Temperature Shift) Converter	3,57	0,05	Above threshold value (NAB)
LTS (Low Temperature Shift) Converter	17,36	0,85	Above threshold value (NAB)

This data represents the maximum number of workers allowed in the noisy area to avoid interfering with their hearing. This is relevant for the IB department area of PT Petrokimia Gresik, where some workers do not wear APT or ear protection equipment, like ear plugs and ear muffs, which are mandatory in areas marked with a specific symbol denoting noise levels above the NAB limit.

Further treatment is needed for the four noise sample measurement areas that exceed the multi-noise standard, so as not to cause occupational diseases, especially the risk of damage or hearing loss caused by the length of exposure time that exceeds the standard.

Workers are allowed to be directly exposed to noise for a predetermined amount of time. If working beyond the specified time limit, workers should use ear protection devices (earmuffs) to allow longer exposure to noise. Buy noise absorbers for equipment that has noise intensity above the NAB such as special boxes or boundary walls in the area.

Limiting working hours at locations that have high noise levels needs to be done by making shift work hours or by rotating workers who previously worked in high noise areas to areas with low noise levels. And further supervision of workers by the Occupational Health and Safety (K3) management section of PT Petrokimia Gresik in the use of PPE (Personal Protective Equipments) and providing information about the dangers of noise to workers' health.

4. Conclusion

PT Petrokimia Gresik, particularly the SPPK sector, has implemented noise control measures. Creating a noise source area map facilitates workers' identification of machines and points that generate noise.

Based on the field measurement results, there are 11 noise points exceeding the quality standards for noise level regulation specified in the Regulation of the Minister of Manpower and Transmigration of the Republic of Indonesia Number Per.13/Men/X/2011 before any control measures are taken. The highest recorded noise level is 106 dB at point 10.

The exposure time recommended by NIOSH varies according to the noise level measurements obtained at each point. Technical abbreviations such as NIOSH should be explained when first used. The maximum permissible exposure time is 34 at point 10.2 minutes is the recommended length of time for workers to be in close proximity to the noise source at PT Petrokimia Gresik. In this case, workers must use earplugs, Earmuffs, and safety hats to reduce the amount of acoustic energy in the hearing mechanism. Additionally, the management of Occupational Health and Safety (K3) PT Petrokimia Gresik should supervise workers in their use of Personal Protective Equipment (PPE) and provide information to workers about the dangers of noise to their health.

The suggested course of action is for the industry at the research location to implement the noise reduction efforts proposed in this study. Further research can be conducted to enhance the effectiveness of these efforts.

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