**International Journal of Eco-Innovation in Science and Engineering (IJEISE)** Vol. 05 (1), 2024 (1-5)
https://ijeise.upnjatim.ac.id/ E-ISSN: 2721-8775

*Article*

# Evaluation of Boiler Feed Water Quality in Tofu Industry UD. FIT in Bocek Village

**Fitri Prihardani**[1,a], **Nida Fariana**[1,b], **Rachmad Ramadhan Yogaswara**[1,c], **Syuaibatul Islamiyah**[1,d*]

1 Department of Chemical Engineering, Faculty of Engineering, Universitas Pembangunan Nasional Veteran Jawa Timur
E-mail: [a]19031010003@student.upnjatim.ac.id, [b]19031010204@student.upnjatim.ac.id, [c]r.yogaswara.tk@upnjatim.ac.id, [d]syuaibatul.tekkim@upnjatim.ac.id
*Corresponding author: syuaibatul.tekkim@upnjatim.ac.id | Phone number: +6285748491556

Received: 08th April 2024; Revised: 27th April 2024; Accepted: 17th May 2024;
Available online: 30th May 2024; Published regularly: May and November

**Abstract**

The UD FIT industry, situated in Bocek Village, Karangploso District, operates as a tofu factory employing modern equipment, including a fire tube boiler. The quality of feed water utilized in the boiler is essential for optimizing its efficiency. This study aimed to analyze the boiler feed water sourced from household wells at UD FIT's tofu factory, using various indicators such as turbidity, iron content, total dissolved solids (TDS), hardness, and pH levels. The test results revealed a temperature of 26°C, TDS of 253 mg/L, turbidity of 4.74 NTU, iron content of 1.123 mg/L, hardness of 180.5 mg/L, and pH of 7.89, with no detectable odor, color, or taste. Based on these findings, it is concluded that the boiler feed water utilized by UD FIT generally meet the quality standards, except for the pH parameter, which is not in accordance with the standard.

**Keywords:** boiler feed water, fire tube boiler, tofu industry, water quality

## 1. Introduction

A boiler, also known as a steam boiler, is a closed vessel wherein water at low pressure is converted into steam with the aid of heat. Within a boiler furnace, the chemical energy in the fuel is converted into heat energy, and the boiler's function is to efficiently transfer that heat to the water within it. Additionally, the boiler must be designed to produce high-quality steam [1].

In Bocek Village, Karangploso subdistrict, Malang regency, numerous tofu industries thrive, among them the UD FIT enterprise. Established nearly a decade ago, this tofu manufacturer yields 8 quintals of tofu daily. Alongside offering traditional white tofu, UD FIT markets processed fried tofu. Their products are predominantly retailed at the Karang Ploso market and in Batu City. In their tofu production process, UD FIT employs modern equipment, including boilers or steam boilers. The utilization of boilers in a tofu factory plays a pivotal role in supporting the primary tofu-making process.

In the tofu industry of UD FIT, a fire tube boiler is employed. The operational principle of this boiler type involves hot gas flowing through the pipes and within the shell containing boiler feed water, which is transformed into steam for the soybean cooking process [2]. The feed water utilized in the factory is sourced from household well water. Besides serving as feed water for the boiler, this well water is also utilized for other processes.

Boiler feed water is a crucial element in the steam generation process. It enters the boiler and undergoes conversion into steam. Maintaining and operating boiler equipment effectively relies heavily on proper treatment of this feed water. As steam is produced, dissolved solids become concentrated, leading to deposits forming within the boiler. This accumulation adversely affects heat transfer and reduces boiler efficiency. It's imperative for boiler feed water to meet

standardized requirements to avoid operational problems. The water should be free from unnecessary minerals and impurities, which can hinder boiler performance [3]. The use of untreated feed water can lead to various issues, impacting the quality and functionality of the steam generation system. These include the formation of sludge and scale, resulting in pipe blockages and overheating [4]. The corrosive nature of water on metals involves complex electrochemical and biochemical processes. No water component is inert to metal, and each can either accelerate or delay corrosion.

To maintain boiler efficiency and prevent the formation of scale and corrosion in the pipes, special attention and maintenance are crucial when treating water intended for evaporation in the boiler. Proper treatment of boiler feed water can significantly prolong the boiler's lifespan. To assess the quality of feed water, water analysis must be conducted regularly, along with the addition of chemicals such as hydrazine, sodium chloride, and phosphate. Phosphate serves to regulate pH levels and acts as a corrosion inhibitor. It binds with $Ca^{2+}$, $Mg^{2+}$, and other impurities present in the boiler components, ensuring that the steam produced is devoid of impurities or contaminants [1].

Following are some of the standard requirements for boiler feed water and boiler water:

Table 1. Standard for boiler & feed water IS:10392-1982 (Altret Performance Chemicals Gujarat Pvt. Ltd)

| **Parameter** | **>20 kg/cm²** | **21-39 kg/cm²** | **40-59 kg/cm²** | **Units** |
|---|---|---|---|---|
| *Hardness* Totals | <10 | <1,0 | <0,5 | Ppm as $CaCO_3$ |
| pH | 8,5-9,5 | 8,5-9,5 | 8,5-9,5 | |
| *Dissolved Oxygen* | 0,1 | 0,02 | 0,01 | As ppm |
| *silica* | | 5 | 0,5 | As ppm $SiO_2$ |

Table 2. Quality standards Boiler feed water (Chem Treat Inc)

| **Parameter** | **Units** | **Measurement** |
|---|---|---|
| pH | | 10,5 – 11,5 |
| Conductivity | µmhos/cm | 5000 max |
| TDS | Ppm | 3500 max |
| P-Alkalinity | Ppm | - |
| M-Alkalinity | Ppm | 800 max |
| O-Alkalinity | Ppm | 2,5 x SiO2 min |
| T Hardness | Ppm | - |
| Silica | Ppm | 150 max |
| Fe | Ppm | 2 max |
| Phosphate Residual | Ppm | - |
| Sulfite residual | Ppm | 20-50 |
| pH condensate | Unit | 8,0-9,0 |

Table 3. Chemical Parameters in the Environmental Health Quality Standards for Water Media based on PERMENKES Number 32 Year 2017 [5]

| **Parameter** | **Units** | **Quality Standards (maximum rate)** |
|---|---|---|
| pH | mg/L | 6,5-8,5 |
| Iron | mg/L | 1 |
| Fluoride | mg/L | 1,5 |
| Hardness ($CaCO_3$) | mg/L | 500 |
| Manganese | mg/L | 0,5 |
| Nitrate, as N | mg/L | 10 |
| Nitrite, as N | mg/L | 1 |
| Cyanide | mg/L | 0,1 |
| Detergent | mg/L | 0,05 |
| Total pesticide | mg/L | 0,1 |

Based on the table above, it is important to analyze boiler feed water at the UD FIT tofu factory to determine the substance content in the feed water used so that boiler performance efficiency can be maximized, as well as maintain boiler life and can maintain tofu production safety.

## 2. Material and Method

DOI:10.4186

This research aims to analyze the feed water used in the boiler equipment at the UD FIT tofu industry located in Bocek Village, Karangploso District, Malang Regency. The analysis process began with a survey of the boiler equipment at the UD FIT tofu factory. Subsequently, samples of the boiler feed water were collected, sourced from household well water. These water samples will undergo testing for parameters including total dissolved solids (TDS), turbidity, iron content, hardness, and pH. The tests were carried out using standardized procedures in Perumda Tugu Tirta Laboratory, Malang Regency.

## 3. Results and Discussion

From the test carried out, the results are presented in the following table:

Table 4. The results of the UD FIT tofu industry feed moisture test results

| Parameter | Units | Test Results |
|---|---|---|
| Smell | - | No Smell |
| Color | TCU | No Color |
| Taste | - | No Taste |
| Temperature | °C | 26 |
| TDS | mg/L | 253 |
| Turbidity | NTU | 4,74 |
| Fe | mg/L | 1,123 |
| Hardness | mg/L | 180,5 |
| pH | - | 7,89 |

### 3.1. Smell, Color and Taste

According to Table 4, the odor parameter indicates that there is no odor in the well water utilized as boiler feed at the UD FIT factory. Similarly, the color parameter reveals the absence of any color in the well water. Additionally, the taste parameter indicates no discernible taste in the UD FIT well water samples. Therefore, based on the data from the well water samples regarding odor, color, and taste parameters at the UD FIT factory, it can be concluded that it meets the requirements for clean water quality in terms of odor.

### 3.2. Temperature and pH

Table 4 illustrates that the temperature parameter of the well water sample from the UD FIT factory was 26°C. This indicates that the water is within standard conditions or meets the requirements, as optimal water temperature typically falls within the normal range of 26°C to 27°C. However, the pH parameter yielded a result of 7.89. This deviates from the pH standard set by Chem Treat Inc., which is 8.0 to 9.0. Additionally, based on the Boiler Feed Water & Boiler Water Standard (IS: 10392-1982), the obtained results also fail to meet the standard range of 8.5 to 9.5. Consequently, it can be concluded that the pH parameters in the UD FIT well water samples do not meet the requirements. Deviation from the set standard pH levels can lead to an increased corrosion rate. Therefore, it is essential to add an alkaline booster to elevate the pH above the predetermined standard and perform blowdown to reduce the pH in the water [3]. Volatile amines and oxygen scavenging compounds can be employed to control the pH value and maintain corrosion control. Achieving pH control can be facilitated by adding an appropriate amount of neutralizer to the feed water using external devices.

### 3.3. TDS (Total Dissolved Solid)

The test results indicated that the TDS (total dissolved solids) had a concentration of 253 mg/L, meeting the standards outlined in Table 2 for boiler feed water quality. Table 2 specifies a maximum allowable content of 3500 ppm for feed water with the TDS indicator. A low TDS value can effectively minimize scale growth, as it suggests a lower concentration of dissolved ions, thereby enhancing heat conductivity within the pipes. Conversely, if the TDS parameter exceeds the established standard, blowdown of the water in the boiler becomes necessary. To mitigate TDS levels, the use of silica sand filtration and softeners is recommended [4].

### 3.4. Iron (Fe) Content

Iron may enter the boiler due to corrosion in the pre-boiler or port portions of the feed system, or it may precipitate out as a result of corrosion

within the boiler itself. Frequently, iron oxide deposits can form and obstruct heat transfer in the boiler tubes, occasionally leading to tube failure. In Table 4, the test results for the iron (Fe) content parameter were 1.123 mg/L. According to the quality standards established by Chem Treat Inc., the maximum requirement for the iron parameter is 2 mg/L. Therefore, the test results indicate that the boiler feed water at the UD FIT tofu factory complies with the boiler feed water quality standard requirements, and the likelihood of scale buildup in the boiler is minimal.

### 3.5. Turbidity

According to PERMENKES No. 32 of 2017, the standard parameters for turbidity indicators specify a maximum level of 25 NTU. Referring to the feed water test results table, the turbidity parameter is recorded at 4.47 NTU. Hence, it can be concluded that the turbidity parameter in UD FIT's boiler feed water meets the standard requirements. It is worth noting that turbidity in water often suggests the presence of soluble organic and inorganic substances [6].

### 3.6. Hardness

The hardness parameter test results show a measurement of 180.5 mg/L, which remains below the standard set by PERMENKES No. 32 of 2017, which is 500 mg/L. When the hardness value exceeds the established standard, the consequences in industry include scale formation in boilers and cooling systems. To mitigate hardness, Sodium Hexa Meta Phosphate is utilized [7].

The quality of the feed water used is not always optimal, thus necessitating a pre-treatment system. This system consists of three stages. The first stage involves pre-filtration before the water is directed to the filtration unit. The FST (Flocculation Settling Tank) is utilized at this stage. It encompasses several processes including coagulation, flocculation, sedimentation, and filtration. Coagulation refers to the process of removing colloidal solids by adding coagulants. During coagulation, colloidal particles are attracted and form agglomerates. Flocculation, a subsequent process after coagulation, involves floc nuclei uniting to form larger flocs, facilitating their precipitation. Sedimentation entails separating a mixture of solids and liquids using gravity to remove suspended solids. Filtration, on the other hand, is a method in which a heterogeneous mixture of liquid and solid particles is separated by a filter that allows the liquid to pass through while retaining the solids [8]. Subsequently, the feed water is demineralized to reduce the ion content, thereby minimizing scale and corrosion.

Additionally, there is also external treatment, which refers to the treatment given before the feed water enters the boiler. In both high- and low-pressure systems on board, the boiler feed water used is typically high-quality distilled water obtained from the evaporation of seawater by the distiller. The evaporation process itself serves to eliminate many harmful constituents. Technically, treatment methods are aimed at reducing alkalinity, hardness, silica, iron, manganese, turbidity, bacteria, organic matter, and other contaminants. In some cases, chemicals are added to remove salt buildup through blowdown procedures [9]. Boiler feedwater treatment plays a crucial role in preventing corrosion, scaling, and overheating.

## 4. Conclusions

The evaluation of UD FIT tofu industrial boiler feed water has been conducted, and the test results are as follows: temperature parameters are 26°C, TDS is 253 mg/L, turbidity is 4.74 NTU, iron content is 1.123 mg/L, hardness is 180.5 mg/L, pH is 7.89, and the water is odorless, colorless, and tasteless. Based on these results, it was concluded that the pH parameters did not meet the established standards, potentially leading to corrosion in the boiler system. Therefore, it is recommended that treatment be performed on the boiler feed water before use. Further analysis regarding the quality of boiler feed water after treatment should be conducted to ensure that the resulting boiler feed water meets the applicable standards.

## References

[1] D. Eka, M. Rusdiantoro, and A. Saleh, "Studi Penurunan Pressure Steam Pada Auxiliary Boiler Di Mv. Situ Mas Yang Mempengaruhi Kinerja Main Engine," *Maj. Ilm. Gema Marit.*, vol. 23, no. 1, pp. 81–85, 2021, doi: 10.37612/gema-maritim.v23i1.128.

[2] M. Fatimura, "Tinjauan Teoritis Permasalahan Boiler Feed Water pada Pengoperasian Boiler yang Dipergunakan dalam Industri," *J. Media Tek.*, vol. 12, no. 1, pp. 24–32, 2015.

[3] Suharso and Buhani, *Penanggulangan Kerak*, 2nd ed. Yogyakarta: Graha Ilmu, 2015.

[4] H. Y. Putri and W. Hadi, "Efektifitas Al2(SO4)3 dan FeCl3 Dalam Pengolahan Air Menggunakan Gravel Bed Flocculator Ditinjau Dari Parameter Warna dan Zat Organik," *J. Tek. Pomits*, vol. 3, no. 2, pp. 167–171, 2014.

[5] Menteri Kesehatan Republik Indonesia, "Peraturan Menteri Kesehatan Republik Indonesia Nomor 32 Tahun 2017 Tentang Standar Baku Mutu Kesehatan Lingkungan Dan Persyaratan Kesehatan Air Untuk Keperluan Higiene Sanitasi, Kolam Renang, Solus Per Aqua dan Pemandian Umum," *Peraturan Menteri kesehatan Republik Indonesia*. pp. 1–20, 2017.

[6] D. Raokhil, I. Fariyya, I. Yulianti, and D. Fianti, "Analysis of Physical Properties of Well Water Quality in Pasuruhan Kidul Kudus Village," *Phys. Commun.*, vol. 5, no. 1, pp. 23–26, 2021, [Online]. Available: http://journal.unnes.ac.id/nju/index.php/pc.

[7] A. Hamzah, A. Subaykto, and A. Surono, "21 Bar Yoshimin Boiler Maintenance with Controlling Residual Phosphate," *IPTEK J. Eng.*, vol. 6, no. 3, p. 47, 2021, doi: 10.12962/j23378557.v6i3.a8117.

[8] Y. Rumbino and K. Abigael, "Determination of Particle Deposition Rate in Water Separation Outcomes of Manganese Oil Washing," *J. Ilm. Teknol. FST Undana*, vol. 14, no. 1, pp. 1–9, 2020.

[9] K. Heselton, *Boiler Operator's Handbook*. Georgia: The Fairmont Press, Inc, 2005.