Assessment Of Non-Destructive Testing Methods For Gold 916: Using Energy Dispersive X-Fluorescence

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Available online 20 June 2023

ABSTRACT

The demand for non-destructive methods to determine the purity of gold 916 has increased significantly due to gold's status as a secure investment. In Malaysia's gold industry, ensuring purity remains a major challenge, as fake gold jewelry containing adulterated gold items, such as gold 916 with significantly lower gold content which is below 91.6 percent, porosity, and undesirable impurities, has become prevalent. In this research project, a methodology is proposed to used one of common method for non-destructive which is Energy Dispersive X-fluorescence (EDXRF) as this method will not destroy the sample during the process to test it. As a result, this research project presented a non-destructive testing method, EDXRF in order to test the authenticity for gold 916 with various compositions.

Keywords: Gold 916, Energy Dispersive X-ray fluorescence (EDXRF), Non-destructive method

1. Introduction

Gold is one of the popular elements in the industry because of its value. Gold is recognized as precious because it is expensive, unique, desirable by most of the worldwide population, and noble [1]. Pure gold is much finer, with a purity of over 99.95 percent, but it is solely used for standards and is not available for jewelry. This is due to pure gold is typically too soft to be utilized for jewelry, additional metals were often added to it, regardless of the tone of gold being prepared for jewelry manufacturing. Many people believe that gold is the finest investment to maintain stock market from falling and inflation. In fact, history suggests that gold performs better during periods of excessive inflation [1].

Purchasing real gold, either gold bar bullion or coins, is the most conventional method of gold investing. According to Malaysian reports, gold investment makes considerable contributions throughout economic instability, particularly when the stock market falls. Kijang Emas Gold Bullion Coins are Malaysia's own gold bullion coins that serve the people an alternative form investing. It has a fineness of 99.99 percent and is sold by BNM through their trusted agent, Maybank. Malaysian banks also sell a diverse selection of real gold goods (bars and coins) to investors, goldsmiths, and coin collectors. A wide range of gold coins are available for investment [2].

The Pawnbroker Act 1972, which was enacted and published in Malaysia, declared that the pawnbroker could not ruin the gold that was to be leased [3]. Densimeters, weighing scales, XRF, needles, chemical solutions, and other instruments are commonly used in Malaysian pawn shops, jewelry stores, and bank branches. Due to legal requirements, tri-electronic, magnet, and stone are used to evaluate gold purity since they are inexpensive, simple, and non-destructive techniques.

Certain methods can only measure the density of the whole sample such as for densimeter and weighing balance. Although these two instruments are easy to use and cheaper to purchase, there is a limitation where it cannot detect the presence of tungsten since the density of gold and tungsten are very close. Past researchers mentioned that the methods that are usually used to assess the purity of the gold is using density measurements such as densimeter and weighing balance but these two methods are useless to detect the presence of tungsten as the density is very close to the pure gold [4].

According to Harian Metro, a man who was lured by a gold investment agent's skill and became a victim of a counterfeit gold fraud involving tungsten metal. The victim who sent the jewelry to be examined at a private laboratory in Wangsa Maju used XRF (X-Ray Fluorescence) equipment before finding that the metal was copper and silver [2]. Also reported in the news that, Enforcement Director of the Ministry of Domestic Trade and Consumer Affairs (KPDNHEP), Azman Adam said that an investigation uncovered 24 complaints connected to gold fraud, with the majority of complainants failing to submit the real amount of damages experienced until May 25. Considering that, the KPDNHEP now has two sets of tools. Since late last year, the X-ray or X-Ray Fluorescence (XRF) device has been used to assess the purity of precious metals such as gold. According to it, the XRF device is a precious metal purity test that is capable of reading the content and composition of more than 100 types of metal elements such as gold, silver, bronze, and others using non-destructive testing methods.

XRF is a non-destructive chemical analysis that is extensively used to assess a material's elemental makeup. XRF is reported to be capable of identifying elements in the Periodic Table ranging from sodium (Na) to uranium (U). X-rays emitted from the surface will have a definite energy with a wavelength characteristic of the atom from which they are formed. As a result, various metals emit X-rays of varying wavelengths [5]. When an X-ray impacts an atom, the atom may release a secondary X-ray with an energy that is unique to the element from which it is emitted. For many years, XRF spectrometry has been used to determine geochemical quantities of a variety of main and trace elements at the parts per million (ppm) level. One of the reasons this technology is so popular is its ability to analyse solid materials using X-ray radiation. Among nuclear methods, X-ray fluorescence (XRF) is the most often used for non-destructive gold assaying [6].

Among nuclear methods, X-ray fluorescence (XRF) is the most widely used for nondestructive gold quality inspection [6]. This approach allows for a volumetric measurement to be conducted without harming the sample while also providing a non-contact measurement. XRF techniques are the best for testing gold purity because they are non-destructive, easy to use, and can handle a wide range of sample sizes. They also have high resolution, an improved detection limit, direct analysis on solid, powder, and liquid samples, save time over conventional equipment, and require minimal sample preparation [7]. In a paper published by [8], four homogeneous materials were studied, each with a different alloy matrix of gold-certified reference. Among the approaches, energy-dispersive X-ray fluorescence spectroscopy (EDXRF) has grown in prominence in recent years. Because of its non-destructive approach, quick test results, and simpler sample preparation, it is a superior alternative to the usual fi re assay method.

2. Materials and Methods

Instrumentation setup This study is a collaboration with the National Metrology Institute of Malaysia (NMIM) to study about gold 916. The experimental flow will begin with the preparation of the gold standard samples of gold 916, which will be provided by NMIM. Energy dispersive X-ray fluorescence (EDXRF) non-destructive testing (NDT) will be used to evaluate all samples. The elemental composition of the samples will be determined. To ensure that the small samples do not fall from the cup holder during testing, the Chemplex SpectroCertified Prolene 4 mm thin film is utilized. This thin film provides a stable surface for the sample, as depicted in the figure below. Thermo ARL Quant EDXRF parameters were set up to match the appropriate energy (keV) of the selected elements, utilizing collimator type 1 with a 1.00 mm diameter beam, an effective diameter of 2.06 mm, and an effective spot area of 3.33mm^2Selecting the correct collimator is crucial for ensuring that the x-ray beam reaches the small diameter target samples as shown in figure 2.2, the targeted area of the sample. The instrument was connected to a PC as shown in figure 2.1 to display the results as a spectrum and percentage. This measurement of EDRF is taken 5 times at different target spot areas and we took the average measurements.

Materials In this study, the samples in figure 2.3 were prepared by NMIM. There will be a few samples with various composition of gold 916. The thickness of the samples has been fixed to 0.40 mm.

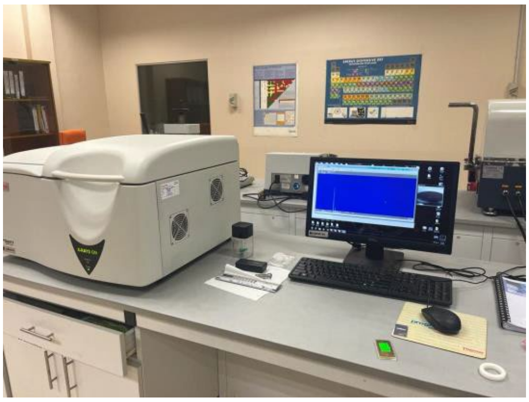

Figure 2.1 Setup for EDXRF and PC for experiment.

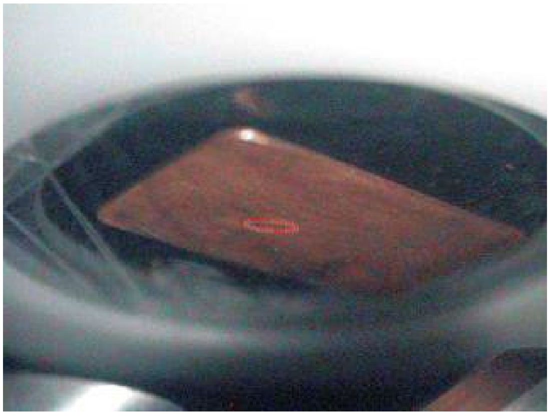

Figure 2.2 Targeted area of the sample to be analysed.

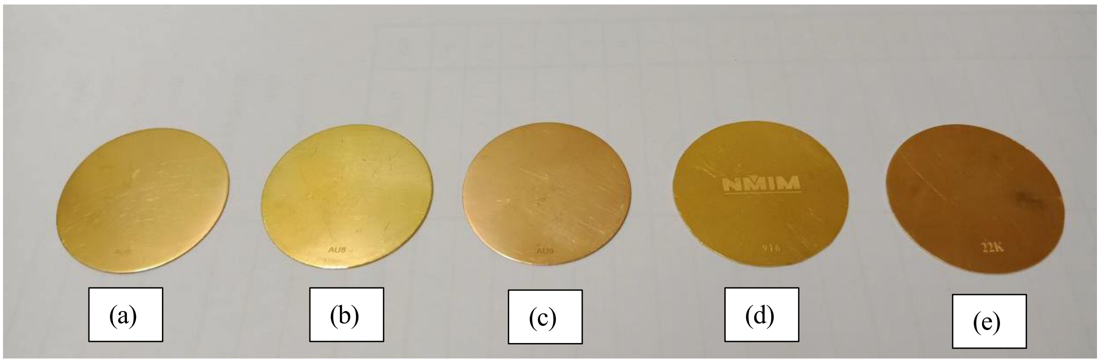

Figure 2.3 The NMIM Gold 916 Standard that used in this study; (a) Au 5, (b) Au 8, (c) Au 9, (d) NMIM and (e) 22k.

3. Results and Discussions

3.1 Energy Dispersive X-Ray Fluorescence (EDXRF).

The EDXRF spectrometer generates a comprehensive spectrum that displays the distinctive peaks of all elements present in the alloy simultaneously. To determine the weight percent composition of the alloy accurately, the regions of observed spectrum peaks are precisely calculated, providing valuable insight into the elemental makeup of the sample. The percentages of each element, copper (Cu), silver (Ag), and gold (Au), in the samples were determined using energy dispersive X-ray fluorescent technology, as can be seen in all of the tables below. figure 3.1 until figure 3.5 shows the one of the spectrum results of the samples and Table 3.1 until Table 3.5 shows one of the results percentages of element contain for each samples. The total number of spectrums included in the study was five graphs for each sample.

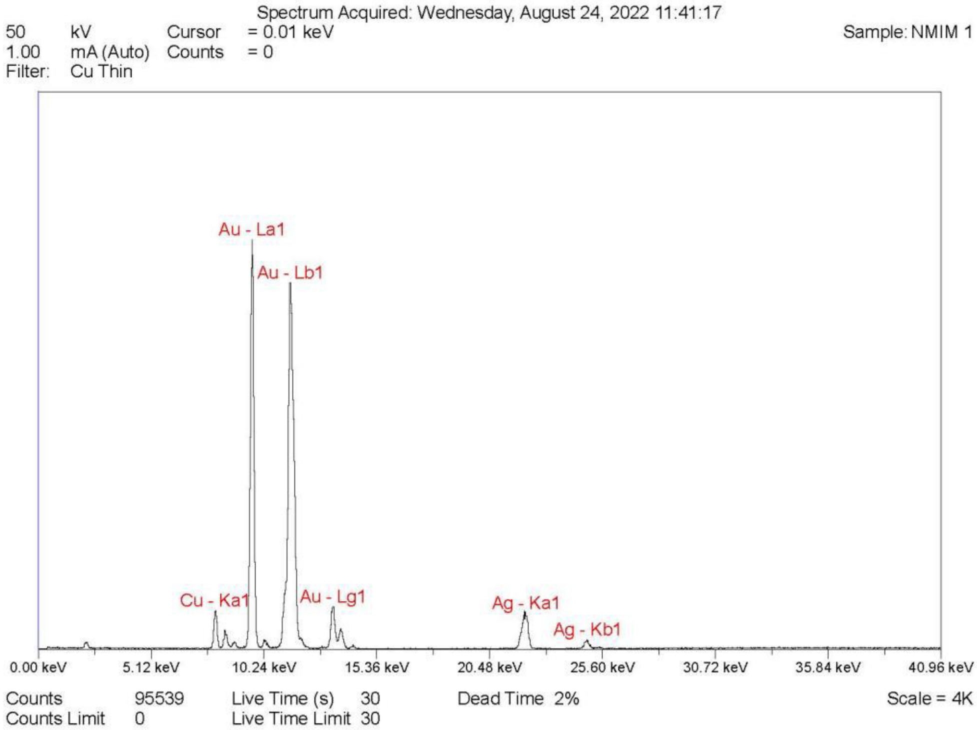

Figure 3.1 Results spectrum of sample NMIM.

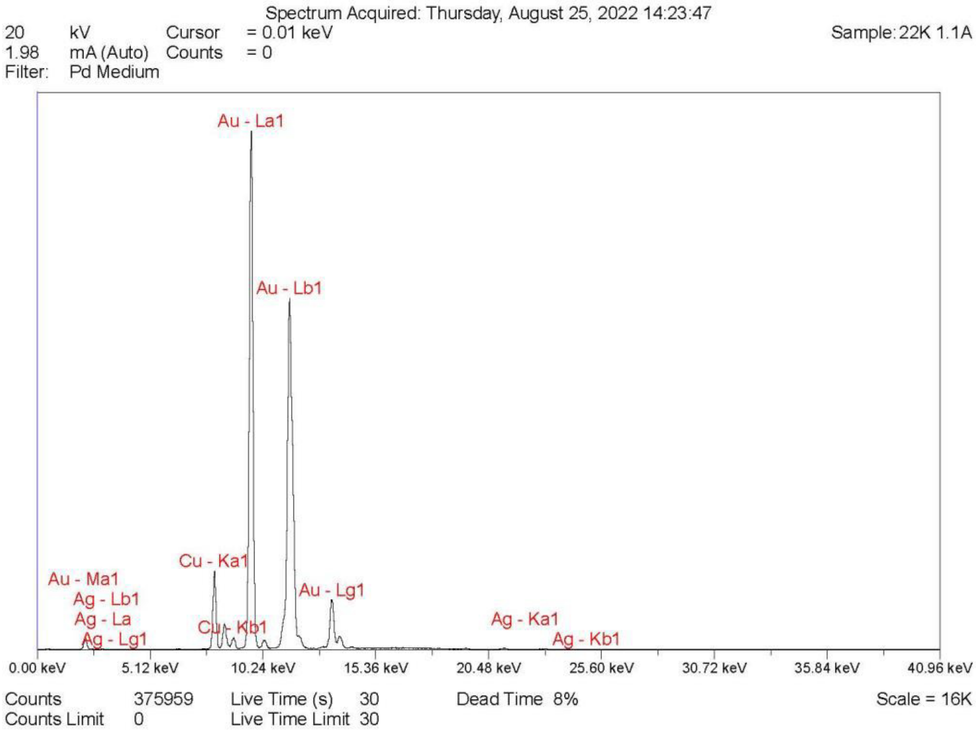

Figure 3.2 Results spectrum for sample 22K.

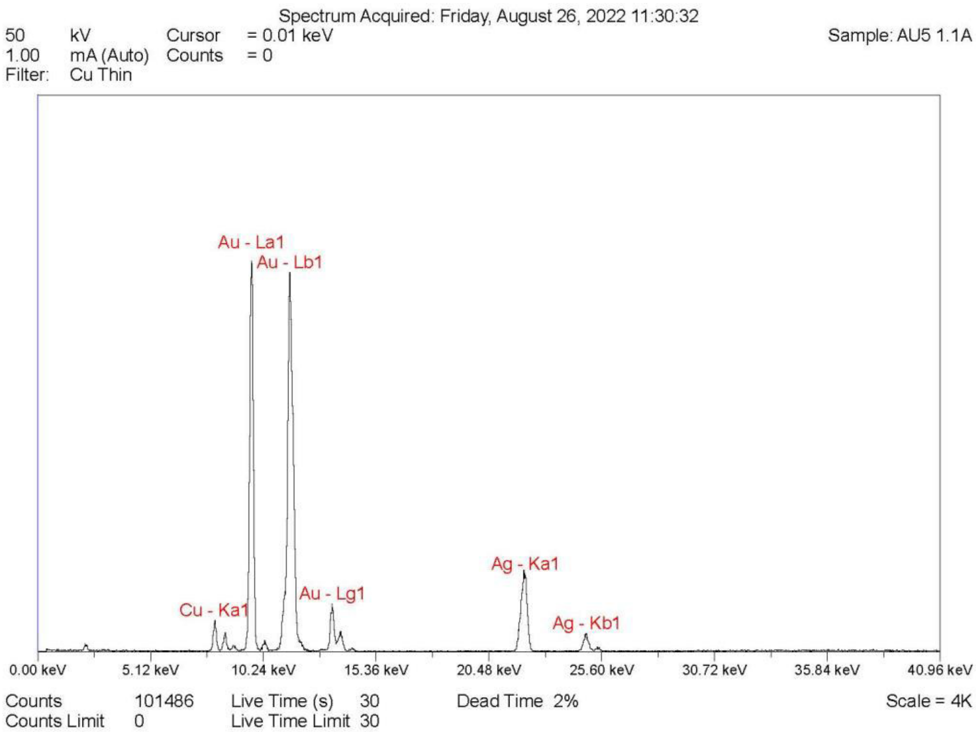

Figure 3.3 Results spectrum for sample AU5.

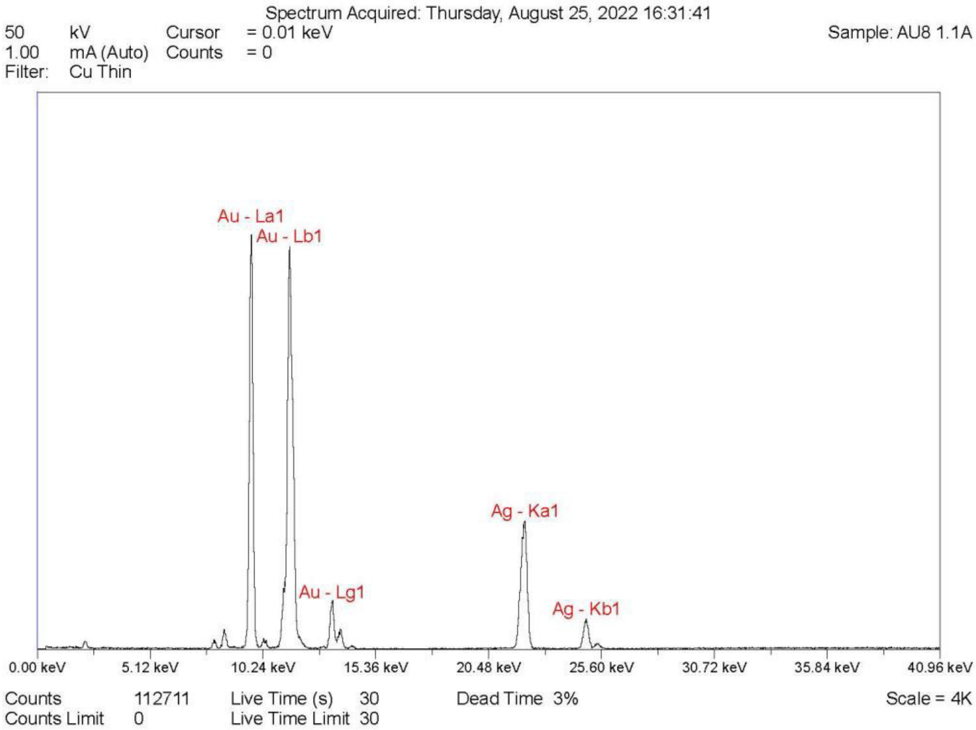

Figure 3.4 Results spectrum for sample Au8.

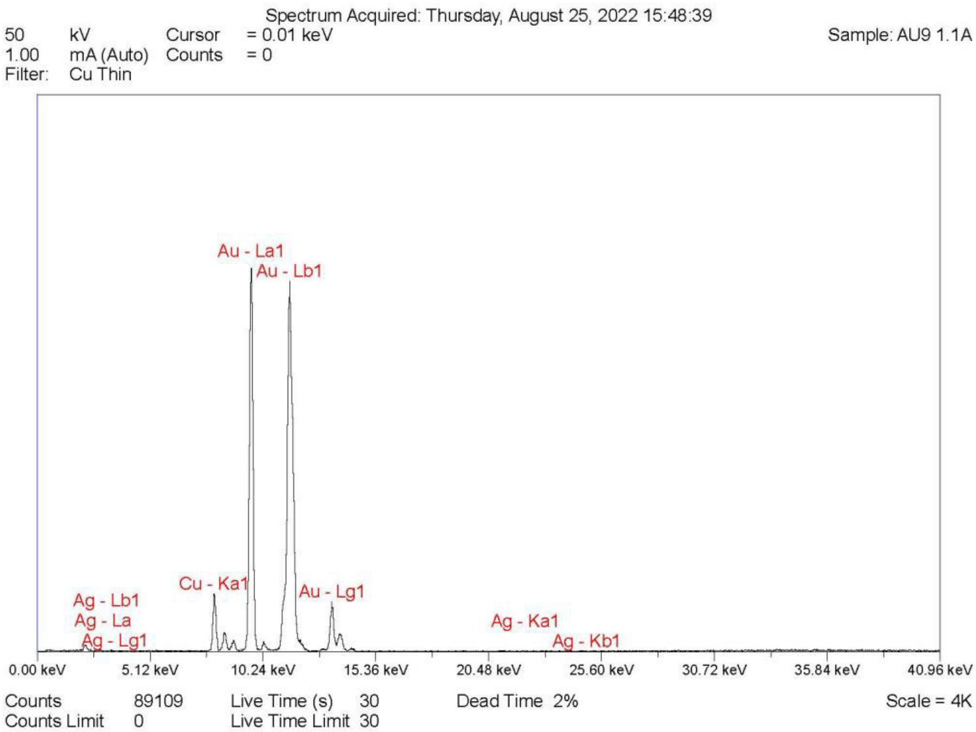

Figure 3.5 Results spectrum for Au9.

Table 3.1 Results of element contain in sample NMIM.

Element	m/m%
Au	93.15
Cu	5.06
Ag	1.79

Table 3.2 Results of element contain in sample 22K

Element	m/m%
Au	92.16
Cu	6.60
Ag	1.24

Table 3.3 Results of elements contain in sample AU5

Element	m/m%
Au	91.99
Cu	4.06
Ag	3.94

Table 3.4 Results of elements contain in sample Au8.

Element	m/m%
Au	92.31
Cu	1.09
Ag	6.60

Table 3.5 Results of elements contain in sample Au9.

Element	m/m%
Au	92.0
Cu	8.00
Ag	0

As shown in the figures , all spectrum of the element contained in the gold alloy was displayed by EDXRF. For figure 3.5 we can see that the peak at lower energy were tagged as Ag Lb1, Ag Lα and Ag Lg1 around 2.5KeV and almost not seen the peak as the element contain was very little. Cu Kα1 peak can be seen at energy around 8.0 KeV. Meanwhile we can see the highest peak at around 9.0 KeV, 11.0KeV and 13.0 KeV labelled as Au Lα1, Au Lb1 and AuLg1. Calculating the regions of detected spectrum peaks for each element in relation to one another and then "matrix-matching" the results to determine the analysis' result were used to determine the alloy's purity. In matrix-matching, measurements of calibration materials with known elemental compositions are compared to measurements of the object being studied.

The elements Au, Cu, and Ag were each found in samples NMIM in amounts of 92.66%, 5.50%, and 1.84%, respectively, by EDXRF. The percentages of the elements present in sample 22k are 92.41% for Au, 6.35% for Cu, and 1.24% for Ag. With respect to Au5, the percentages are 3.98 for Cu and 4.05% for Ag. The percentages for Cu are 1.10, 6.72% for Ag, and 92.17 for Au8. Finally, Ag was not found in Au9, which only contains 92% Au and 8% Cu.
These results has been summarized in Table 3.6 below.

Table 3.6 Percentage composition of copper, silver and gold of the samples.

	% Au	%Cu	%Ag
NMIM	92.66	5.50	1.84
22K	92.41	6.35	1.24
AU5	91.97	3.98	4.05
AU8	92.17	1.10	6.72
AU9	92.00	8.00	0.00

4. Conclusion

The Energy-Dispersive X-ray Fluorescence (EDXRF) analysis technique is essential in providing helpful information into the elemental composition of alloys and estimating the amounts of various elements contained within a material. When this method is used to examine gold 916 samples, EDXRF is useful in identifying various composition differences including Copper (Cu), Silver (Ag), and Gold (Au).

ACKNOWLEDGEMENT

The authors would like to acknowledge the financial support from the Ministry of Education Malaysia under Fundamental Research Grant Scheme (FRGS) (FRGS/1/2022/TK07/UTM/02/59).

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