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# Pipe Wall Thickness Comparison of Seamless, ERW, and SAW Type for Steam Piping System

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**Abstract:- This research aims to compare the wall thickness calculations for seamless, electric resistance welded (ERW), and submerged arc welded (SAW) pipes in steam piping systems, focusing on the ASME B31.1 code. The findings highlight significant disparities in wall thickness among these pipe types. Seamless pipes require a smaller wall thickness compared to ERW and SAW pipes due to the absence of weld seams. This eliminates weak points and reduces stress concentrations, allowing seamless pipes to achieve the required strength with a smaller wall thickness. In contrast, ERW pipes exhibit a slightly higher wall thickness requirement due to the presence of longitudinal and circumferential weld seams, necessitating additional thickness to ensure adequate strength and compensate for stress concentrations. SAW pipes generally necessitate a larger wall thickness compared to seamless pipes but have a lower requirement than ERW pipes, attributed to their manufacturing process. The presence of weld seams in ERW and SAW pipes introduces areas of potential stress concentration, requiring additional thickness. Consideration of manufacturing processes and weld seams is essential in determining the appropriate wall thickness for steam piping systems. Seamless pipes offer advantages in terms of reduced thickness and fewer weak points, while ERW and SAW pipes remain viable options based on specific characteristics and required strength levels. Future research should explore additional factors, including temperature, pressure, corrosion resistance, and project requirements, to facilitate informed decision-making for efficient, reliable, and cost-effective steam piping systems.**

***Keywords:-*** *Steam Piping System, Wall Thickness, ASME B31.1, Seamless, Electric Resistance Welded, Submerged Arc Welded.*

## I. INTRODUCTION

The design and analysis of piping systems are critical in the power and process industries. The steam pipe is one of the main requirements for the plant to be installed[1]. Ensuring the proper wall thickness of pipes is crucial for maintaining the structural integrity and safety of these systems. The ASME B31.1 Power Piping[2]. The code provides guidelines and standards for the design, construction, and operation of power piping systems, including steam piping[3].

The selection of pipe type is an essential aspect of steam piping design, and different types of pipes have their own advantages and limitations[4]. Seamless pipe is formed by piercing a solid, near molten, steel rod, called a billet, with a mandrel to produce a pipe that has no seams or joints[5]. ERW pipes formed with the roll forming process show a yield stress distribution along the circumferential direction and their quality is strongly influenced by the magnitude and by the distributions of the yield stress[6]. SAW arc welding process which produces the coalescence of metals by heating them with an arc or arcs between a bare metal electrode or electrodes and the work[7].

The determination of pipe wall thickness is critical to ensure that the pipes can withstand internal pressure and other operational stresses[8]. ASME B31.1 Power Piping provides detailed equations and procedures for calculating the minimum required wall thickness based on factors such as operating conditions, material properties, and safety factors[9]. Codes and standards were established to provide methods of manufacturing, listing, and reporting design data[10].

The selection of appropriate pipe material and dimensions is a critical aspect in the design and construction of a steam piping system[4]. The steam piping system, an integral part of various industrial processes, is responsible for transporting high-pressure and high-temperature steam from the source to the desired destination[11]. The efficiency, safety, and overall performance of the system heavily rely on the characteristics of the pipes used, particularly their wall thickness.

This research aims to compare the wall thickness of three commonly used pipe types for steam piping systems such as seamless, electric resistance welded (ERW), and submerged arc welded (SAW) to select the most efficient and effective wall thickness.

The subsequent sections of this research will discuss the methodology employed for comparing the wall thickness of seamless, ERW, and SAW pipes because the three pipe types have different properties when calculated. The results of the calculation comparison, highlight the key findings and implications for steam piping system design and operation. By considering the advantages and limitations of each pipe type, the research assists in optimizing the performance, efficiency, and safety of steam piping systems across diverse industries.

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## II. METHODOLOGY

Steam is a high-pressure and high-temperature fluid, and thus, the piping system must be designed to withstand these challenging operating conditions[12]. Factors such as design pressure, temperature, and material properties are considered when determining the appropriate wall thickness[13].

Seamless, ERW, and SAW. Each type has distinct characteristics in terms of the manufacturing process, structural integrity, and applicability. Seamless pipes are manufactured without any welding seams, ERW pipes are created by electric resistance welding, and SAW pipes are formed through submerged arc welding[14]. Understanding the differences in their manufacturing processes is essential for comprehending the subsequent wall thickness comparisons.

ASME B31.1 provides a systematic approach to ensure the safety and reliability of power piping systems. It covers a wide range of topics, including materials, design considerations, fabrication, inspection, testing, and maintenance of power piping[15]. The code aims to achieve consistent and standardized practices in the industry to mitigate risks and ensure compliance with applicable regulations. This includes understanding the specific provisions and equations provided by the code for calculating the minimum require pipe wall thickness[16].

One of the important aspects addressed by ASME B36.10 standards of Welded and Seamless Wrought Steel Pipe is the wall thickness of the pipes[17]. ASME B36.10 is a widely recognized standard that provides specifications for the design and construction of steel pipes. This standard is commonly used in various industries, including oil and gas, petrochemical, and power generation.

During the manufacturing process, steel pipes undergo dimensional variations known as mill tolerances. The mill tolerances also become a consideration in the calculation of pipe wall thickness[18]. Nominal wall thicknesses designate a wall thickness that can vary, plus or minus, by some specified manufacturing tolerance[19]. The mill tolerances value of pipe seamless and welded pipe is shown in standard API Spec 5L table 11 tolerances for wall thickness[20].

### *A. Steam Piping Data*

The steam piping data information that provides data for pipe size, material, and design conditions in this research is shown in Table 1 below.

Table 1. Steam Piping Data

| ***Pipe Size (inch)*** | ***Pipe Material*** | ***Design Pressure (bar)*** | ***Design Temperature (°C)*** | ***Corrosion Allowance (mm)*** |
|---|---|---|---|---|
| 6” | API 5L Gr. B | 45 | 170 | 3 |
| 8” | API 5L Gr. B | 45 | 170 | 3 |
| 12” | API 5L Gr. B | 45 | 170 | 3 |
| 14” | API 5L Gr. B | 45 | 170 | 3 |
| 16” | API 5L Gr. B | 45 | 170 | 3 |
| 18” | API 5L Gr. B | 45 | 170 | 3 |
| 20” | API 5L Gr. B | 45 | 170 | 3 |
| 22” | API 5L Gr. B | 45 | 170 | 3 |
| 24” | API 5L Gr. B | 45 | 170 | 3 |

### *B. Calculation Method*

The types of pipe manufacturing of Seamless, Electric Resistance Welded (ERW), and Submerged Arc Welded (SAW) of API 5L Gr. B material has different parameters in calculation. The design parameters of the three types referred to as the standard ASME B31.1 Power Piping are shown in Table 2 below.

Table 2. Design Parameters of API 5L Gr. B Pipe

| ***Pipe Types for*** | ***Maximum Allowable Stress in (bar) (SE)*** | ***Weld Strength Reduction Factor (W)*** | ***Coefficient (y)*** |
|---|---|---|---|
| Seamless | 1179.003 | 1 | 0.4 |
| ERW (Electric Resistance Welded) | 1006.635 | 1 | 0.4 |
| SAW (Submerged Arc Welded) | 1061.793 | 1 | 0.4 |

The equation to calculate the wall thickness using the equation from ASME B31.1 Power Piping.

$$t_m = \frac{PDo}{2(SEW + Py)} + A \qquad (1)$$

Where:

*tm* = The minimum required wall thickness (mm)
*P* = The internal design pressure (bar)
*Do* = The outside diameter of the pipe (mm)
*SE* = The maximum allowable stress in the material due to internal pressure and joint efficiency (bar)
*W* = Weld strength reduction factor
*y* = The material coefficient

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*A* = The corrosion allowance (mm)

For the minimum specified wall thickness (t') is determined by considering the manufacturing tolerances.

t' = t – Tol (2)

Where
t' = Minimum Specified Wall Thickness (mm)
t = Nominal Thickness Selected (mm)
Tol= The Mill Tolerances (mm)

Each pipe size and type of pipe manufacturer follows the equation to calculate and compare the value of wall thickness. The minimum specified wall thickness shall be greater than the minimum required wall thickness.

## III. RESULT AND DISCUSSION

The results of the comparative analysis of pipe wall thickness for Seamless, ERW, and SAW types in steam piping systems. The discussion focuses on the implications of the findings, highlighting the strengths and weaknesses of each pipe type in relation to wall thickness requirements.

In order to determine the thinnest required wall thickness among seamless, ERW, and SAW (Submerged Arc Welding) pipes, a comprehensive analysis was conducted by calculating the wall thickness for each type of pipe material and subsequently comparing the results. This comparison involved evaluating the wall thickness requirements for seamless pipes, ERW pipes, and SAW pipes in order to identify the type of pipe with the minimum thickness needed.

### A. Wall Thickness Calculation of Seamless Pipe

The process of determining the calculation for wall thickness involved the utilization of the ASME B31.1 equation. This calculation was performed for a range of pipe sizes, specifically from 6 inches to 24 inches. The comprehensive results of the wall thickness calculation for seamless pipes can be found in Table 3, demonstrating the outcome of the detailed calculations. Please refer to the table below for the Wall Thickness Calculation Result of Seamless Pipe

Table 3. Wall Thickness Calculation Result of Seamless Pipe

| ***Pipe Size*** | ***Design Pressure*** | ***Design Temp.*** | ***Outside Diameter*** | ***Nominal Thickness Selected*** | ***Mill Tolerances*** | ***Maximum Allowable Stress*** | ***Coefficient*** | ***Weld Strength Reduction Factor*** | ***Minimum Required Wall Thickness*** | ***Corrosion Allowance*** | ***Minimum Specified Wall Thickness*** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ***P*** | ***P*** | ***Do*** | ***t*** | ***Tol*** | ***SE*** | ***y*** | ***W*** | ***tm*** | ***A*** | ***t'*** |
| ***inch*** | ***bar*** | ***°C*** | ***mm*** | ***mm*** | ***mm*** | ***bar*** | ***-*** | ***-*** | ***mm*** | ***mm*** | ***mm*** |
| 6” | 45 | 170 | 168.3 | 7.11 | 0.88 | 1179.003 | 0.4 | 1 | 6.187 | 3 | 6.221 |
| 8” | 45 | 170 | 219.1 | 8.18 | 1.02 | 1179.003 | 0.4 | 1 | 7.149 | 3 | 7.157 |
| 10” | 45 | 170 | 273 | 11.13 | 1.39 | 1179.003 | 0.4 | 1 | 8.170 | 3 | 9.738 |
| 12” | 45 | 170 | 323.8 | 11.13 | 1.39 | 1179.003 | 0.4 | 1 | 9.132 | 3 | 9.738 |
| 14” | 45 | 170 | 355.6 | 11.13 | 1.39 | 1179.003 | 0.4 | 1 | 9.734 | 3 | 9.738 |
| 16” | 45 | 170 | 406.4 | 12.7 | 1.58 | 1179.003 | 0.4 | 1 | 10.696 | 3 | 11.112 |
| 18” | 45 | 170 | 457 | 14.27 | 1.78 | 1179.003 | 0.4 | 1 | 11.655 | 3 | 12.486 |
| 20” | 45 | 170 | 508 | 15.09 | 1.88 | 1179.003 | 0.4 | 1 | 12.621 | 3 | 13.203 |
| 22” | 45 | 170 | 559 | 15.88 | 1.98 | 1179.003 | 0.4 | 1 | 13.587 | 3 | 13.895 |
| 24” | 45 | 170 | 610 | 17.48 | 2.18 | 1179.003 | 0.4 | 1 | 14.553 | 3 | 15.295 |

The results indicate that the wall thickness of seamless pipe is variative depending on the pipe size. As the pipe diameter increases, the wall thickness tends to increase as well. This correlation is influenced by the outer diameter of the pipe.

### B. Wall Thickness Calculation of ERW Pipe

The calculation methodology used for determining the wall thickness of seamless pipes is also applied to ERW (Electric Resistance Welding) pipes. Consequently, the comprehensive calculation results for the wall thickness of ERW pipes can be found in Table 4, presented below. This table provides detailed information regarding the wall thickness calculation for the ERW pipe type.

Table 4. Wall Thickness Calculation Result of ERW Pipe

| ***Pipe Size*** | ***Design Pressure*** | ***Design Temp.*** | ***Outside Diameter*** | ***Nominal Thickness Selected*** | ***Mill Tolerances*** | ***Maximum Allowable Stress*** | ***Coefficient*** | ***Weld Strength Reduction Factor*** | ***Minimum Required Wall Thickness*** | ***Corrosion Allowance*** | ***Minimum Specified Wall Thickness*** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ***P*** | ***P*** | ***Do*** | ***t*** | ***Tol*** | ***SE*** | ***y*** | ***W*** | ***tm*** | ***A*** | ***t'*** |
| ***inch*** | ***bar*** | ***°C*** | ***mm*** | ***mm*** | ***mm*** | ***bar*** | ***-*** | ***-*** | ***mm*** | ***mm*** | ***mm*** |
| 6” | 45 | 170 | 168.3 | 7.92 | 0.792 | 1006.635 | 0.4 | 1 | 6.728 | 3 | 7.128 |
| 8” | 45 | 170 | 219.1 | 8.74 | 0.874 | 1006.635 | 0.4 | 1 | 7.853 | 3 | 7.866 |
| 10” | 45 | 170 | 273 | 11.13 | 1.113 | 1006.635 | 0.4 | 1 | 9.047 | 3 | 10.017 |
| 12” | 45 | 170 | 323.8 | 12.7 | 1.27 | 1006.635 | 0.4 | 1 | 10.173 | 3 | 11.43 |
| 14” | 45 | 170 | 355.6 | 12.7 | 1.27 | 1006.635 | 0.4 | 1 | 10.877 | 3 | 11.43 |
| 16” | 45 | 170 | 406.4 | 14.27 | 1.427 | 1006.635 | 0.4 | 1 | 12.003 | 3 | 12.843 |
| 18” | 45 | 170 | 457 | 15.88 | 1.5 | 1006.635 | 0.4 | 1 | 13.124 | 3 | 14.38 |
| 20” | 45 | 170 | 508 | 15.88 | 1.5 | 1006.635 | 0.4 | 1 | 14.254 | 3 | 14.38 |
| 22” | 45 | 170 | 559 | 17.48 | 1.5 | 1006.635 | 0.4 | 1 | 15.383 | 3 | 15.98 |
| 24” | 45 | 170 | 610 | 19.05 | 1.5 | 1006.635 | 0.4 | 1 | 16.513 | 3 | 17.55 |

The wall thickness calculation for Electric Resistance Welding (ERW) pipes has a maximum allowable stress that is lower than that of seamless pipes, which subsequently affects the required value of the wall thickness.

*C. Wall Thickness Calculation of SAW Pipe*

The calculation results for the wall thickness of the SAW pipe have been illustrated and are available for reference in Table 5. Wall Thickness Calculation Result of SAW Pipe. Specifically, the aforementioned table displays the outcome of the wall thickness calculation conducted on the SAW pipe. This vital information pertaining to the wall thickness can also be found in the subsequent content in below.

Table 5. Wall Thickness Calculation Result of SAW Pipe

| ***Pipe Size*** | ***Design Pressure*** | ***Design Temp.*** | ***Outside Diameter*** | ***Nominal Thickness Selected*** | ***Mill Tolerances*** | ***Maximum Allowable Stress*** | ***Coefficient*** | ***Weld Strength Reduction Factor*** | ***Minimum Required Wall Thickness*** | ***Corrosion Allowance*** | ***Minimum Specified Wall Thickness*** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ***P*** | ***P*** | ***Do*** | ***t*** | ***Tol*** | ***SE*** | ***y*** | ***W*** | ***tm*** | ***A*** | ***t'*** |
| ***inch*** | ***bar*** | ***°C*** | ***mm*** | ***mm*** | ***mm*** | ***bar*** | ***-*** | ***-*** | ***mm*** | ***mm*** | ***mm*** |
| 6” | 45 | 170 | 168.3 | 7.92 | 0.792 | 1061.793 | 0.4 | 1 | 6.536 | 3 | 7.128 |
| 8” | 45 | 170 | 219.1 | 8.74 | 0.874 | 1061.793 | 0.4 | 1 | 7.603 | 3 | 7.866 |
| 10” | 45 | 170 | 273 | 11.13 | 1.113 | 1061.793 | 0.4 | 1 | 8.736 | 3 | 10.017 |
| 12” | 45 | 170 | 323.8 | 12.7 | 1.27 | 1061.793 | 0.4 | 1 | 9.803 | 3 | 11.43 |
| 14” | 45 | 170 | 355.6 | 12.7 | 1.27 | 1061.793 | 0.4 | 1 | 10.472 | 3 | 11.43 |
| 16” | 45 | 170 | 406.4 | 14.27 | 1.427 | 1061.793 | 0.4 | 1 | 11.539 | 3 | 12.843 |
| 18” | 45 | 170 | 457 | 14.27 | 1.427 | 1061.793 | 0.4 | 1 | 12.602 | 3 | 12.843 |
| 20” | 45 | 170 | 508 | 15.88 | 1.5 | 1061.793 | 0.4 | 1 | 13.674 | 3 | 14.38 |
| 22” | 45 | 170 | 559 | 17.48 | 1.5 | 1061.793 | 0.4 | 1 | 14.745 | 3 | 15.98 |
| 24” | 45 | 170 | 610 | 17.48 | 1.5 | 1061.793 | 0.4 | 1 | 15.817 | 3 | 15.98 |

The outcome derived from the analysis of the wall thickness for the Submerged Arc Welding (SAW) pipe reveals that the measured value of the wall thickness is comparatively lower than that of the Electric Resistance Welding (ERW) pipe but higher than that of the seamless pipe. This disparity in wall thickness values can be attributed to the distinctive maximum allowable stress levels assigned to each type of pipe during their respective manufacturing processes. It is evident that the calculation of the wall thickness is greatly influenced by the varying maximum allowable stress values associated with the different types of pipe manufacturing techniques.

*D. Wall Thickness Required Comparison*

Figure 1. Comparison of Required Wall Thickness presents a meticulously detailed graph that effectively highlights the distinct characteristics of each type of pipe. This graph provides comprehensive insights into the variations in required wall thickness across different pipe sizes and manufacturing processes.

Notably, it visually demonstrates that each pipe size, based on its specific manufacturing technique, necessitates a unique wall thickness. Furthermore, a discernible trend emerges from the graph, indicating that as the pipe size increases from small to large, the corresponding wall

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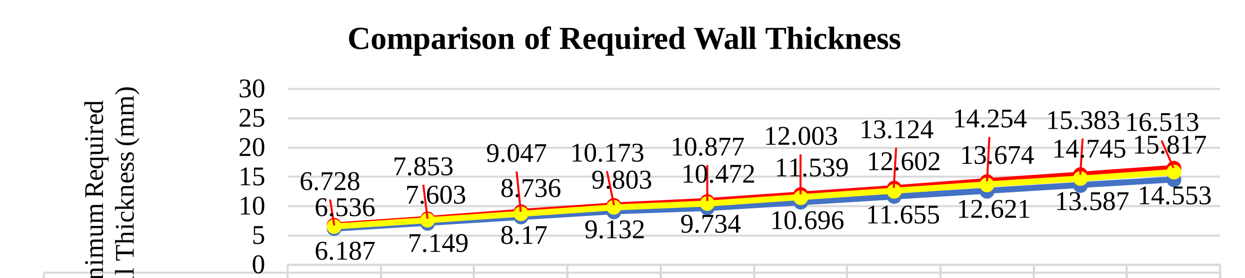
thickness also exhibits a proportional increase. This graph serves as an invaluable visual aid, enabling a comprehensive understanding of the intricate relationships between pipe size, manufacturing process, and the associated requirements for wall thickness.




| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Seamless Pipe | 6.187 | 7.149 | 8.17 | 9.132 | 9.734 | 10.696 | 11.655 | 12.621 | 13.587 | 14.553 |
| ERW Pipe | 6.728 | 7.853 | 9.047 | 10.173 | 10.877 | 12.003 | 13.124 | 14.254 | 15.383 | 16.513 |
| SAW Pipe | 6.536 | 7.603 | 8.736 | 9.803 | 10.472 | 11.539 | 12.602 | 13.674 | 14.745 | 15.817 |
| Pipe Size (Inch) | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |

Fig. 1. Comparison of Required Wall Thickness

Seamless pipes tend to have a relatively smaller wall thickness requirement compared to ERW and SAW pipes in steam piping systems. This can be attributed to the absence of weld seams, which eliminates potential weak points and reduces stress concentrations.

In contrast to seamless pipes, ERW pipes exhibit a slightly higher wall thickness requirement due to the presence of longitudinal and circumferential weld seams. The analysis reveals the impact of these weld seams on stress distribution and the resulting need for a slightly thicker wall to ensure adequate strength.

The findings demonstrate that SAW pipes generally necessitate a larger wall thickness compared to seamless but lower than ERW pipes in steam piping systems. This is primarily due to the welding or manufacturing process that determining the allowable stress of each type of the pipe.

## IV. CONCLUSION

The findings indicate distinct differences in wall thickness among these pipe types, driven by their respective manufacturing processes and the presence or absence of weld seams.

Seamless pipes were found to have a relatively smaller wall thickness requirement compared to ERW and SAW pipes in steam piping systems. This can be attributed to the absence of weld seams in seamless pipes, which eliminates potential weak points and reduces stress concentrations. The absence of weld seams contributes to a more uniform stress distribution, enabling seamless pipes to achieve the required strength with a smaller wall thickness.

On the other hand, ERW pipes exhibited a slightly higher wall thickness requirement due to the presence of longitudinal and circumferential weld seams. The analysis revealed that these weld seams have an impact on stress distribution, necessitating a slightly thicker wall to ensure adequate strength. The presence of weld seams introduces areas of potential stress concentration, which require additional thickness to compensate for the reduced structural integrity.

In comparison, SAW pipes generally necessitated a larger wall thickness compared to seamless pipes but had a lower requirement than ERW pipes in steam piping systems. The welding or manufacturing process employed in SAW pipes contributes to their higher wall thickness requirement. The allowable stress for each type of pipe is determined by the welding or manufacturing process, which leads to a higher wall thickness for SAW pipes compared to seamless pipes but lower than that of ERW pipes.

These findings emphasize the importance of considering the manufacturing process and the presence of weld seams when determining the appropriate wall thickness for steam piping systems. Seamless pipes offer advantages in terms of reduced wall thickness requirements and fewer potential weak points. However, ERW and SAW pipes can still be viable options, considering their specific characteristics and the level of strength required for the given application.

Further research and analysis are recommended to explore additional factors influencing the wall thickness requirements of different pipe types and their performance in steam piping systems. These factors may include temperature, pressure, corrosion resistance, and specific project requirements. Understanding these factors will facilitate informed decision-making in selecting the most suitable pipe type for steam piping systems based on considerations of efficiency, reliability, and cost-effectiveness.

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