

# Pressure Drop Evaluation in Avtur Fuel Pipelines Using the Darcy-Weisbach Method

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**Abstract** - The use of aviation fuel (avtur) as the primary fuel in the aviation industry demands an efficient, safe, and standard-compliant distribution system. One important aspect of the aviation fuel distribution piping system is the pressure drop that can affect flow performance. The main problem studied in this internship is the magnitude of the pressure drop in the aviation fuel distribution pipeline that has the potential to reduce operational efficiency. The purpose of this study is to calculate and analyze the magnitude of pressure loss using the Darcy-Weisbach method and to identify the dominant factors that influence pressure drop. The methodology used includes literature studies, collection of pipe and fluid technical data, calculation of flow velocity, Reynolds number, friction factor, and evaluation of major and minor pressure losses. The analysis results show that the aviation fuel flow velocity of 1.64 m/s is still within the safe distribution standard limit. The total pressure drop that occurs is 27,914 Pa (0.279 bar), with a contribution of more than 98% coming from minor losses due to connections, valves, and elbows, while major losses are relatively small. This finding confirms that pipeline design optimization needs to focus on reducing additional components with high loss coefficients to improve the efficiency of the aviation fuel distribution system.

**Keywords:** Fluid flow, Avtur, Darcy-Weisbach, Pressure loss, Minor losses.

## I. INTRODUCTION

The use of aviation fuel (avtur) plays a vital role in the aviation industry as the primary energy source for aircraft [1]. Avtur must be distributed through a pipeline from storage tanks to filling points with maintained quality and quantity [2]. A crucial aspect of this distribution system is ensuring that the flow of avtur remains stable, efficient, and complies with applicable aviation safety standards [3]. Therefore, technical analysis of fluid flow in the pipeline, including pressure drop, is crucial [4].

Pressure drop occurs due to friction between the fluid and the pipe walls and the presence of additional components such as joints, valves, and bends [5]. If the pressure drop is too

large, avtur distribution can become inefficient, potentially even disrupting aircraft filling operations [6]. Therefore, evaluating pressure drop is a crucial step to ensure the piping system operates according to its design capacity and is capable of safely delivering aviation fuel [7].

One widely used method for calculating pressure drop in fluid flow is the Darcy-Weisbach method [8]. This method is known to be quite accurate because it takes into account pipe friction, pipe length, diameter, flow velocity, and the properties of the flowing fluid [9]. Using the Darcy-Weisbach equation, pressure drop calculations can be systematically performed, allowing the results to be used as a reference in evaluating the design and operational conditions of aviation fuel pipelines [10].

In the context of fuel storage and distribution facilities in the aviation industry, this method is highly relevant [11]. Evaluation using the Darcy-Weisbach approach can help companies determine whether their pipelines still meet performance standards or require repairs or modifications [12]. This is crucial for maintaining a smooth aviation fuel supply chain while minimizing potential losses due to suboptimal distribution.

Furthermore, pressure drop studies also support safety aspects [13]. Aviation fuel pipeline systems must be designed to minimize the risk of leaks or damage due to excessive pressure [14]. Pressure drop analysis allows early identification of potential problems and the implementation of preventive measures [15]. This aligns with risk management principles applied in the oil and gas and aviation industries, where safety is always a top priority.

Based on this description, evaluating pressure drop in aviation fuel pipelines using the Darcy-Weisbach method is crucial, especially for internships focused on fuel distribution systems. The evaluation results are expected to provide a real picture of the performance of the piping system, as well as serve as a reference in efforts to improve efficiency, reliability, and operational safety in aviation fuel storage and distribution facilities.

## II. MATERIAL AND METHOD

### 2.1 Fluids and Flow in Pipes

A fluid is a substance that can flow and adapt to the shape of its container, including liquids and gases [16]. In fluid mechanics, fluid flow in pipes is a common application, particularly in fuel, water, and industrial gas distribution systems. Fluid flow in pipes is influenced by the physical properties of the fluid, the pipe geometry, and the acting external forces. Important parameters in fluid flow include flow velocity, viscosity, density, and pressure [17].

Pipe flow can be distinguished as laminar and turbulent, determined by the Reynolds number (Re). Flow is considered laminar if  $Re < 2300$ , transitional if  $2300 < Re < 4000$ , and turbulent if  $Re > 4000$ . These flow characteristics significantly influence the friction factor value used in pressure loss calculations [18].

### 2.2 Pressure drop

Pressure drop is the decrease in fluid pressure along a pipe flow due to friction with the pipe walls and additional components such as valves, connections, and bends. Pressure loss can be divided into two categories: major losses – pressure loss due to fluid friction with the pipe walls along the flow and minor losses – pressure loss due to additional components in the piping system, such as valves, fittings, bends, and pipe narrowing/widening.

The magnitude of the pressure drop is crucial to analyze because it affects the performance of the fluid distribution system. If the pressure drop is too large, additional pumping power or improved pipe design are required to maintain efficient fluid distribution.

### 2.3 Factors Affecting Pressure Drop

Several main factors influence pressure drop in fluid flow through pipes, including: Pipe Length ( $L$ ) – The longer the pipe, the greater the pressure loss. Pipe Diameter ( $D$ ) – Pipes with small diameters produce higher flow velocities, resulting in greater friction and increased pressure drop. Flow Velocity ( $V$ ) – The greater the fluid velocity, the greater the energy lost due to friction. Fluid Physical Properties – Density ( $\rho$ ) and viscosity ( $\mu$ ) affect the Reynolds number and flow characteristics. Pipe Surface Roughness ( $\epsilon$ ) – Pipes with rough surfaces will create higher friction than smooth pipes. Additional Components – Valves, elbows, reducers, and other fittings add minor losses to the system.

### 2.4 Darcy–Weisbach Equation

The Darcy–Weisbach equation is a fundamental method for calculating major pressure losses in fluid flow in pipes. This equation is stated as follows [19]:

$$H_f = f \cdot \frac{L}{D} \cdot \frac{V^2}{2g}$$

Where:

$H_f$  = pressure loss (m)

$f$  = friction factor (dimensionless)

$L$  = pipe length (m)

$D$  = pipe diameter (m)

$V$  = fluid flow velocity (m/s)

$g$  = gravitational acceleration (9.81 m/s<sup>2</sup>)

To calculate pressure loss in terms of pressure, the equation is used:

$$\Delta P = \rho \cdot g \cdot h_f$$

where,  $\rho$  = fluid density (kg/m<sup>3</sup>).

### 2.5 Friction Factor

The friction factor ( $f$ ) in the Darcy–Weisbach equation depends on the flow conditions:

Laminar Flow ( $Re < 2300$ )

$$f = \frac{64}{Re}$$

Turbulent Flow ( $Re > 4000$ )

Using the Colebrook–White equation approach:

$$\frac{1}{f} = -2 \log_{10} \left( \frac{\epsilon}{3.7D} + \frac{2.51}{Re \sqrt{f}} \right)$$

where  $\epsilon$  = pipe roughness (m).

For practical solutions, the Moody diagram is typically used as a reference to determine the value of  $f$  based on the Reynolds number and pipe roughness ratio.

### 2.6 Minor Pressure Loss

Minor head loss is calculated using the equation:

$$H_m = K \cdot \frac{V^2}{2g}$$

Where:

$H_m$  = minor head loss (m)

$K$  = loss coefficient for fittings or valves (dimensionless)

$V$  = fluid velocity (m/s)

The total head loss in a piping system is the sum of major and minor losses:

$$P_{total} = P_f + \sum P_m$$

The right-hand flow loss formula is as follows:

$$P_m = \rho \times g \times H_m$$

### 2.7 Avtur as a Working Fluid

Aviation Turbine Fuel (avtur) is a kerosene-type liquid fuel used in aircraft turbine engines. Avtur has different physical properties than water, including a density of approximately 775–840 kg/m<sup>3</sup> and a kinematic viscosity of 1.3–1.9 cSt at 15°C. These characteristics affect the Reynolds number and the calculation of pressure loss in the pipeline system.



Figure 1: Pipelines

In fuel distribution systems, avtur must be pumped through pipelines (as in Figure 1) at maintained pressure to meet aviation safety standards. Therefore, pressure drop analysis using the Darcy–Weisbach method is highly relevant to ensure smooth flow and distribution efficiency.

## III. RESULTS AND DISCUSSIONS

### 3.1 Technical Data

The following table presents the main data of the aviation fuel piping system which is the basis for calculating pressure drop using the Darcy–Weisbach method.

Table 1: Technical Data

No.	Parameter	Value / Data
1	Pipe diameter ( $D$ )	0,1016 m

2	Total pipe length ( $L$ )	28,15 m
3	Flow rate ( $Q$ )	0,0133 m <sup>3</sup> /s (800 LPM)
4	Aviation fuel density ( $\rho$ )	796 kg/m <sup>3</sup>
5	Fluid temperature	27 °C
6	Fluid type	Avtur

### 3.2 Calculation Results

With the above data, it will be used to evaluate the pressure drop using the Darcy–Weisbach method.

#### 3.2.1 Flow Velocity ( $V$ )

The flow velocity is calculated using the equation:

$$V = \frac{Q}{A}$$

With a flow rate of  $Q=0.0133 \text{ m}^3/\text{s}$  and a pipe cross-sectional area of  $A=0.0081 \text{ m}^2$ , we obtain:

$$V = \frac{0,0133}{0,0081} = 1,64 \text{ m/s}$$

A velocity of 1.64 m/s indicates that the fluid is flowing steadily and not too high, so the risk of cavitation or fluid vibration is relatively low. This value is in accordance with fuel distribution standards, which are generally below 2 m/s [20].

#### 3.2.2 Reynold Number ( $Re$ )

The Reynolds number is used to determine the characteristics of fluid flow. The equation is:

$$Re = \frac{V \cdot D}{\nu}$$

With a flow velocity of  $V=1.64 \text{ m/s}$ , a pipe diameter of  $D=0.1016 \text{ m}$ , and a kinematic viscosity of aviation fuel of  $\nu=1.5 \times 10^{-6} \text{ m}^2/\text{s}$ , we obtain:

$$Re = \frac{1,64 \times 0,1016}{1,5 \times 10^{-6}} = 1,1 \times 10^5$$

This value indicates that the flow is turbulent.

#### 3.2.3 Friction Factor ( $f$ )

Under turbulent flow conditions, the friction factor is determined using a Moody diagram, taking into account the Reynolds number and the roughness of the steel pipe. The calculation yields:

$$f = 0,018$$

This value indicates a relatively low level of friction, indicating that the pipe is still in good condition. The major pressure loss due to friction along the pipe is calculated using the Darcy–Weisbach equation:

$$\Delta Pf = f \cdot \frac{L}{D} \cdot \frac{\rho V^2}{2}$$

With  $f=0.018$ ,  $L=28.15\text{m}$ ,  $D=0.1016$ ,  $\rho=796\text{ kg/m}^3$  and  $V=1.64\text{ m/s}$ , we obtain:

$$\Delta Pf = 514\text{ Pa} = 0,005\text{ bar}$$

This value is relatively small compared to the total pressure drop in the system.

### 3.2.5 Minor Pressure Loss ( $\Delta Pm$ )

Minor losses come from fittings, valves, and elbows. The equation is:

$$\Delta Pm = \frac{K \cdot \rho V^2}{2}$$

With the total loss coefficient  $K$  from all connections, the result is:

$$\Delta Pm = 27.400\text{ Pa} = 0,274\text{ bar}$$

This value is much greater than the major losses, making it the primary cause of pressure drop.

### 3.2.6 Total Pressure drop ( $\Delta P_{total}$ )

The total pressure drop is calculated by summing the major and minor losses:

$$\Delta P_{total} = \Delta Pf + \Delta Pm$$

$$\Delta P_{total} = \Delta Pf + \Delta Pm$$

$$\Delta P_{total} = 514 + 27.400 = 27.914\text{ Pa} = 0,279\text{ bar}$$

This result indicates that more than 98% of the pressure drop comes from minor losses. Therefore, piping design needs to consider the number and type of connections to ensure the system operates more efficiently [21].

### 3.3 Discussion of Calculation Results

Based on calculations using the Darcy–Weisbach method, the jet fuel flow velocity in the pipe was 1.64 m/s. This value indicates that the flow is stable and meets the generally recommended liquid fuel distribution standards of less than 2 m/s, thus avoiding the risk of cavitation or excessive fluid vibration [20]. The Reynolds number calculation showed a value of  $1.1 \times 10^5$ , indicating that the flow is in a turbulent regime. This condition is normal in pressurized fuel piping systems and affects the pipe friction factor.

The obtained friction factor value was 0.018, consistent with the conditions of the steel pipe used. Using this value, the pressure loss due to friction along the pipe (major losses) was calculated at 514 Pa or approximately 0.005 bar. This result is relatively small, so it can be concluded that the pipe length does not significantly affect the total pressure drop.

In contrast, calculations of pressure loss due to additional components (minor losses) such as elbows, valves, and connections showed a much higher value, at 27,400 Pa, or approximately 0.274 bar. These results confirm that the primary factor causing pressure drop in the aviation fuel piping system is the number and type of fittings used [21].

Overall, the total pressure drop was 27,914 Pa, or 0.279 bar. This figure is still relatively small compared to the pump capacity used in the aviation fuel distribution system, but it still indicates that minor losses contribute more than 98% of the total pressure loss. Therefore, this analysis suggests that pipeline optimization is more effective by reducing the number of fittings or selecting components with lower loss coefficients, rather than solely considering pipe length.

## IV. CONCLUSION

Based on the analysis using the Darcy–Weisbach method on the aviation fuel piping system, the results showed that the flow velocity of 1.64 m/s is within reasonable limits for the distribution of liquid fuel. The Reynolds number value of  $1.1 \times 10^5$  indicates that the flow is in turbulent conditions, in accordance with the characteristics of the pressure piping system. Major pressure loss due to friction along the pipe is only 514 Pa (0.005 bar), while minor losses due to fittings, valves, and connections are much greater, namely 27,400 Pa (0.274 bar). Thus, the total pressure drop that occurs is 27,914 Pa (0.279 bar), where more than 98% of the pressure drop is caused by minor losses. This confirms that additional components in the piping line are the dominant factor in influencing pressure drop, not the length of the pipe itself.

## REFERENCES

- [1] Subiakto, Y. (2025). Kesiapan Teknisi Awak Pesawat Udara Menghadapi Pajanan Bahan Toksik Di Bandar Udara. *Jurnal Manajemen Kesehatan Dan Keperawatan*, 1(4), 166-175.
- [2] Akmal, M. E. M. (2025). Implementasi Quality Control Avtur Di Aviation Fuel Terminal (Aft) Ahmad Yani Semarang.
- [3] Amat, C. (2024). Book Chapter Manajemen Bandara.
- [4] Jalaluddin, J., Akmal, S., & Ishak, I. (2019). Analisa Profil Aliran Fluida Cair Dan Pressure Drop Pada Pipa L Menggunakan Metode Simulasi Computational Fluid

- Dynamic (Cfd). *Jurnal Teknologi Kimia Unimal*, 8(1), 97-108.
- [5] Rumaherang, E. J., Wattimena, W. M. E., Rawulun, S. M., & Noya, E. (2023). Studi Regim Aliran Fluida Dan Penentuan Head Loss Akibat Gesekan Pada Instalasi Perpipaan. *Ale Proceeding*, 6, 154-161.
- [6] Rahma, H. N. (2019). *Rancang Bangun Simulator Penyaringan Bahan Bakar Dengan Menggunakan Katup Bypass Pada Sistem Distribusi Bahan Bakar Pesawat Terbang (Perhitungan Biaya Produksi)(Perhitungan Biaya Produksi)* (Doctoral Dissertation, Politeknik Negeri Sriwijaya).
- [7] Darmasetiawan, I. M. (2025). *Sistem Perpipaan Distribusi Air Minum*. Pt Kimhsafi Alung Cipta.
- [8] Eswanto, E., & Syahputra, D. (2017). Analisa Distribusi Kapasitas Aliran Fluida Di Daerah Percabangan Pada Sistem Perpipaan. *Jtt (Jurnal Teknologi Terapan)*, 3(1).
- [9] Jody, A. (2024). *Rancang Bangun Alat Peraga Pipa Uji Rugi-Rugi Aliran Dengan Mesin Pompa Air Otomatis* (Doctoral Dissertation, Universitas Muhammadiyah Sumatera Barat).
- [10] Harahap, P. (2025). *Kajian Head Loss Pengujian Dan Operasi Jaringan Ekstensi Pipa Gas Mdpe 180 Mm Pgn Perumahan Bintaro Jaya* (Doctoral Dissertation, Universitas Mercu Buana Jakarta).
- [11] Revalina, F. A., Harviana, N. F., Pratama, I. L., Aji, F., & Annasit, A. (2025). *Inovasi Penyaluran Bahan Bakar Minyak (Bbm) Menggunakan Teknologi Drone*. Pt. Star Digital Publishing, Yogyakarta-Indonesia.
- [12] Bohalima, I. (2024). *Evaluasi Jaringan Pipa Air Minum Di Kota Gunungsitoli Menggunakan Program Epanet 2.0*.
- [13] Juita, R., & Fitriyani, D. (2019). Analisis Tingkat Sirkulasi Alamiah Pada Liquid Metal Fast Breeder Reactor Dengan Pendingin Na, NaK, Pb Dan Pb-Bi. *Jurnal Fisika Unand*, 8(3), 227-233.
- [14] Salim, A. A. (2025). Optimalisasi Perawatan Pipa Muatan Manifold Guna Mencegah Kebocoran Muatan Di Mt. Orkim Discovery.
- [15] Sari, M., Wahyuni, C. U., & Rahayu, T. P. (2025). Analisis Masalah Kesehatan Pada Program Hipertensi Di Dinas Kesehatan Kota Kediri Tahun 2024. *Jurnal Epidemiologi Kesehatan Komunitas*, 10(2), 10-18.
- [16] Rahman, M. M., & Karim, M. M. (2021). Review Of Fluid Mechanics Principles And Their Applications In Engineering. *Materials Today: Proceedings*, 46, 4806–4813.
- [17] Basuki, I., & Susanto, F. (2019). Aliran Fluida Laminer Pada Pipa Non Horizontal. *Jeecae (Journal Of Electrical, Electronics, Control, And Automotive Engineering)*, 4(2), 301-305.
- [18] Day, M. F. (2024). *Analisa Tekanan Dan Debit Aliran Pada Sistem Manifold Pipa Ballast Kapal Tb. Bukit Prima 02= Pressure And Flow Debit Analysis In Ship Ballast Pipe Manifold System Tb. Bukit Prima 02* (Doctoral Dissertation, Universitas Hasanuddin).
- [19] Wulandari, D. F., Subekti, A., & Nugroho, A. T. (2025). Optimization Of Water Distribution Based On Head Loss Analysis Using Epanet Software. *Berkala Sainstek*, 13(2), 109-118.
- [20] Cengel, Y. A., & Cimbala, J. M. (2018). *Fluid Mechanics: Fundamentals And Applications*. Mcgraw-Hill Education.
- [21] Munson, B. R., Okiishi, T. H., Huebsch, W. W., & Rothmayer, A. P. (2013). *Fundamentals Of Fluid Mechanics*. Wiley.

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