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Instrument Air Compressors: The Lifeline of Oil and Gas Facility. Volume 1. A Case Study of Oml 17 – Nigeria

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Abstract:- Instrument air compressors (IACs) play a pivotal role as the backbone of oil and gas facilities, providing essential compressed air to power critical instruments and pneumatic systems. (Thomas Paulose, 2024). Instrument air is a critical component in the oil and gas industry. It is compressed air that is used to power instruments and control systems that are used in the production, processing, and transportation of oil and gas. (EY, 2020). This paper delves into the indispensable significance of IACs in ensuring the reliable and safe operation of oil and gas facilities, elucidating their crucial role in various operational processes, including control systems, safety devices, and process instrumentation. Through a thorough examination of the importance of instrument air in the oil and gas industry, this paper emphasizes the paramount importance of maintaining optimal performance and reliability of IACs. It discusses the key challenges and considerations associated with ensuring the continuous supply of instrument air, encompassing equipment reliability, energy efficiency, and maintenance practices. Furthermore, the paper explores effective strategies for optimizing instrument air compressor performance, encompassing proactive maintenance, technological advancements, and operational enhancements. (Abhishek Kumar et al 2021). Utilizing case studies and real-world examples, the paper illustrates the profound impact of proficient instrument air compressor management on overall facility reliability, safety, and operational efficiency. In conclusion, this paper underscores the critical recognition of instrument air compressors as indispensable assets within oil and gas facilities. (EY, 2020). It emphasizes the imperative for proactive management and optimization to uphold their continued reliability and efficacy. (Paul J. Holdcroft et al, 2015) By prioritizing the maintenance and performance of IACs, oil and gas operators can elevate facility operations, mitigate risks, and uphold the industry's commitment to safety and environmental stewardship.

Keywords:- *Instrument Air Compressors, Oil and Gas Facilities, Compressed Air, Safety, Control Systems, Pneumatic Equipment, Maintenance Practices, Energy Efficiency, Optimization, Proactive Monitoring, Equipment Reliability, Technological Advancements, Operational Efficiency.*

I. INTRODUCTION

Instrument air compressors (IACs) stand as indispensable components within the intricate operations of oil and gas facilities, serving as the lifeline that powers critical instruments and pneumatic systems essential for operational success. (John Smith et al, 2020). In the dynamic environment of oil and gas (production and processing, the reliable and efficient functioning of IACs is paramount to ensure operational continuity, safety, and productivity

This paper delves into the pivotal role of IACs within oil and gas facilities, elucidating their significance in various operational processes such as control systems, safety devices, and process instrumentation. By providing a steady supply of compressed air, IACs facilitate the operation of pneumatic equipment used for valve actuation, process control, and safety interlocks, among other vital functions.

Furthermore, the introduction explores the multifaceted challenges and considerations associated with managing and maintaining IACs within oil and gas facilities. From ensuring equipment reliability to optimizing energy efficiency and implementing effective maintenance practices, oil and gas operators face a myriad of complexities in managing their instrument air systems.

Through this exploration, the introduction sets the stage for a comprehensive examination of instrument air compressors, highlighting their critical importance as the lifeline of oil and gas facilities. By recognizing the indispensable role of IACs and understanding the challenges and opportunities in their management, oil and gas operators can strive towards enhancing facility reliability, safety, and operational efficiency.

II. MATERIALS AND METHODS

A. Site Description:

The overview of the oil and gas facility under study, including its location, operational scope, and infrastructure layout as shown in figure 1.

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Describe the instrumentation air compressor systems installed at the facility, including their specifications, capacities, and configurations.

B. Data Collection:

Gather operational data related to the instrument air compressor systems, including air pressure levels, flow rates, temperature, and power consumption as shown in the table below.

Collect historical maintenance records, including maintenance schedules, repair logs, shown in table 1, and any previous optimization efforts undertaken at the facility.

Conduct interviews or surveys with facility personnel, including operators, maintenance technicians, and engineers, to gather insights into operational practices and challenges related to instrument air compressor management.

C. Performance Assessment:

Analyze the collected data to assess the current performance of the instrument air compressor systems at the facility.

Evaluate key performance indicators (KPIs) such as compressor uptime, air quality, energy efficiency, and maintenance frequency.

Identify any operational inefficiencies, equipment malfunctions, or maintenance issues affecting compressor performance.

D. Root Cause Analysis:

Conduct a root cause analysis to identify underlying factors contributing to suboptimal instrument air compressor performance.
Utilize tools such as fault tree analysis, fishbone diagrams, or failure mode and effects analysis (FMEA) to systematically identify and categorize potential causes of performance issues.

Table 1: Instrument Air Compressor FLM Log Sheet

Air Compressor A															
PARAMETER	NORMAL RANGE	MONDAY		TUESDAY		WEDNESDAY		THURSDAY		FRIDAY		SATURDAY		SUNDAY	
		10AM	10PM	10AM	10PM	10AM	10PM	10AM	10PM	10AM	10PM	10AM	10PM	10AM	10PM
Operating condition	RN/SD/DN	SB	SB	SB	SB	RN	RN	SB	SB	RN	RN	SB	SB	SB	SB
Running hours		SB	SB	SB	SB	88694	88718	SB	SB	88730	88742	SB	SB	SB	SB
1st stage discharge temp	120°C	SB	SB	SB	SB	N/A	105	SB	SB	2.6	2.6	SB	SB	SB	SB
1st stage discharge pressure	3.2 bar	SB	SB	SB	SB	2.5	11.0	SB	SB	102	102	SB	SB	SB	SB
2nd stage discharge temp	<130 °C	SB	SB	SB	SB	103	2.3	SB	SB	11.3	11.3	SB	SB	SB	SB
2nd stage discharge pressure	<12bar	SB	SB	SB	SB	11.0	99	SB	SB	2.5	2.5	SB	SB	SB	SB
Lube oil pressure	2.1–3.0 bar	SB	SB	SB	SB	2.3	25	SB	SB	95	95	SB	SB	SB	SB
Auxiliary water temperature inlet	80 °C	SB	SB	SB	SB	97	97	SB	SB	25	25	SB	SB	SB	SB
Auxiliary water temperature outlet	<60 °C	SB	SB	SB	SB	25	25	SB	SB	25	25	SB	SB	SB	SB
Air compressor B															
PARAMETER	NORMAL RANGE	MONDAY		TUESDAY		WEDNESDAY		THURSDAY		FRIDAY		SATURDAY		SUNDAY	
		10AM	10PM	10AM	10PM	10AM	10PM	10AM	10PM	10AM	10PM	10AM	10PM	10AM	10PM
Operating condition	RN/SD/DN	RN	RN	RN	RN	DN	DN	RN	RN	SB	RN	RN	RN	RN	RN
Running hours		88658	88670	88682	88694	-	-	88713	88724	88732		88745	88755	88769	88780
1st stage discharge temp	120°C	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

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1st stage discharge pressure	**3.2 bar**	**2.4**	**2.5**	**2.5**	**2.5**	**SB**	**SB**	**2.5**	**2.5**	**SB**	**SB**	**2.6**	**2.6**	**2.6**	**2.6**
2nd stage discharge temp	**<130 °C**	**105**	**103**	**105**	**SB**	**SB**	**SB**	**102**	**102**	**SB**	**SB**	**102**	**103**	**102**	**101**
2nd stage discharge pressure	**<12bar**	**11.0**	**11.0**	**11.0**	**SB**	**SB**	**SB**	**11.8**	**11.2**	**SB**	**SB**	**11.3**	**11.3**	**11.4**	**11.4**
Lube oil pressure	**2.1–3.0 bar**	**2.2**	**2.3**	**2.3**	**2.3**	**SB**	**SB**	**2.4**	**2.3**	**SB**	**SB**	**2.5**	**2.5**	**2.5**	**2.5**
Auxiliary water temperature inlet	**80 °C**	**97**	**97**	**99**	**96**	**SB**	**SB**	**98**	**96**	**SB**	**SB**	**95**	**94**	**95**	**96**
Auxiliary water temperature outlet	**<60 °C**	**25**	**25**	**25**	**25**	**SB**	**SB**	**25**	**25**	**25**	**SB**	**25**	**25**	**25**	**25**

E. Optimization Strategies:

Develop targeted optimization strategies based on the findings of the performance assessment and root cause analysis.

Prioritize interventions that address the most critical performance issues while considering factors such as cost-effectiveness, feasibility, and potential impact on operational efficiency. (Ahmed Ali et al, 2022)

Explore various optimization approaches, including equipment upgrades, maintenance optimization, operational adjustments, and the implementation of advanced monitoring and control systems.

F. Implementation Plan:

Outline a detailed plan for implementing the identified optimization strategies, including timelines, resource allocation, and responsible stakeholders.

Define key performance targets and metrics to track the effectiveness of optimization efforts over time.

Consider the need for training and capacity building to ensure successful implementation and ongoing maintenance of optimized compressor systems. (Rachel Adams, et al, 2023)

G. Monitoring and Evaluation:

Establish a monitoring and evaluation framework to track the progress and outcomes of optimization initiatives.

Continuously monitor compressor performance against established KPIs and benchmarks, (Sarah Lee et al, 2021).

- **Instrument Air Compressors**: These are the primary equipment pieces, typically reciprocating or rotary screw compressors, specifically designed to provide clean and dry compressed air for instrument and control systems. (Robert Johnson et al, 2019). Shown in figure 1.

Fig 1: Showing Air Reciprocating Compressor System Showing Compressor Control Panel, Gauges, Sump, and Discharge Drum etc.

- **Air filter**: Essential for removing contaminants such as dust, oil, and moisture from the intake air to ensure the quality of the compressed air. Shown in figure 3.
- **Air Dryers**: Used to remove moisture from the compressed air to prevent corrosion and damage to instrumentation. Figure 3.

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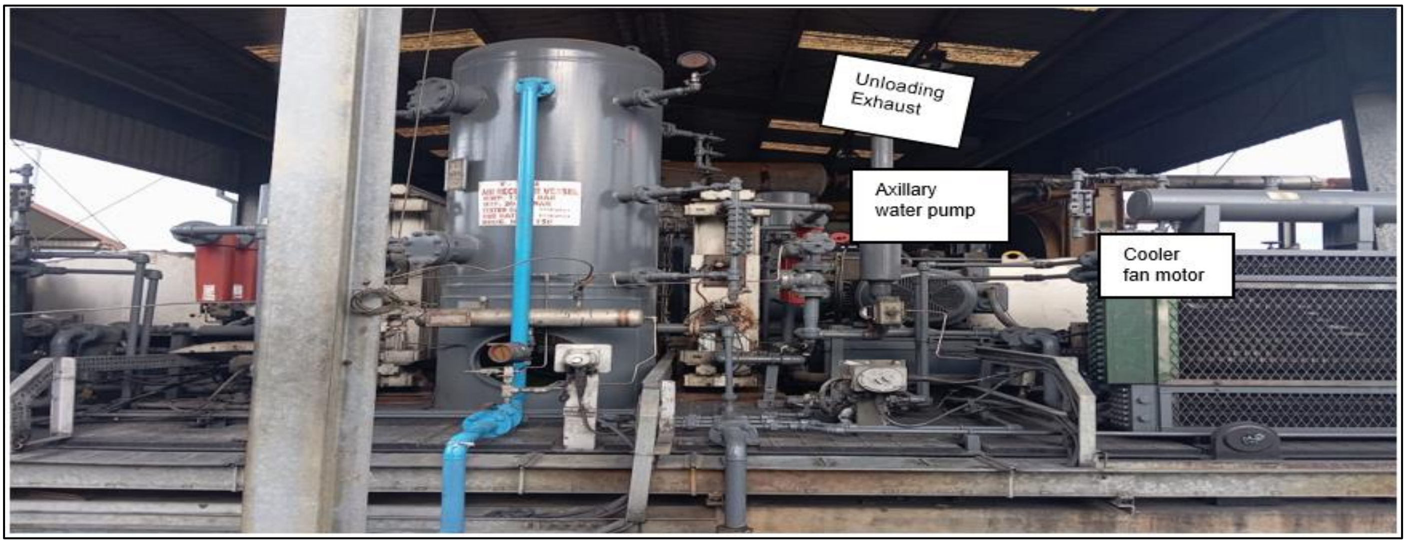

Fig 2: Shows Cooler Fan Motor, Auxiliary Water Pump and Unloading Exhaust

- **Piping and Tubing**: Distribution network to carry the compressed air from the compressors to various instruments and control systems throughout the facility. Shown in figure 3.
- **Pressure Regulators and Control Valves**: Regulate and control the pressure of the compressed air as required by different instruments and systems.
- **Instrumentation**: Various gauges, sensors, and control devices that rely on compressed air for operation.

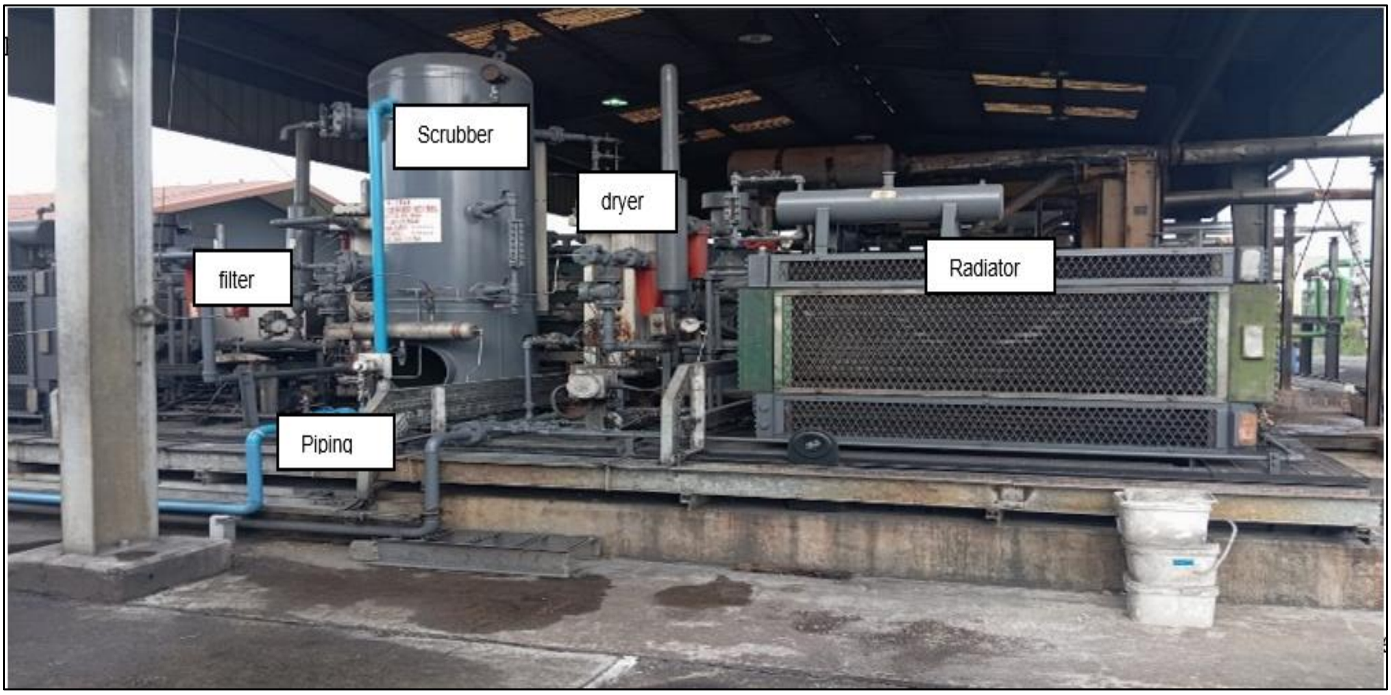

Fig 3: Shows Instrument Air Compressor Scrubber, Filters, Radiators, Dryers, Tubing & Piping, etc.

- **Lubricants and Coolants**: Required for lubrication and cooling in reciprocating compressors, ensuring smooth operation and longevity. Shown in figure 3.
- **Safety Equipment**: Including pressure relief valves as shown in figure 4, pressure gauges, and alarms to ensure safe operation and prevent overpressure situations.

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Fig 4: Showing Air Receiver, Relief Valve and the Piping and Instrumentation System

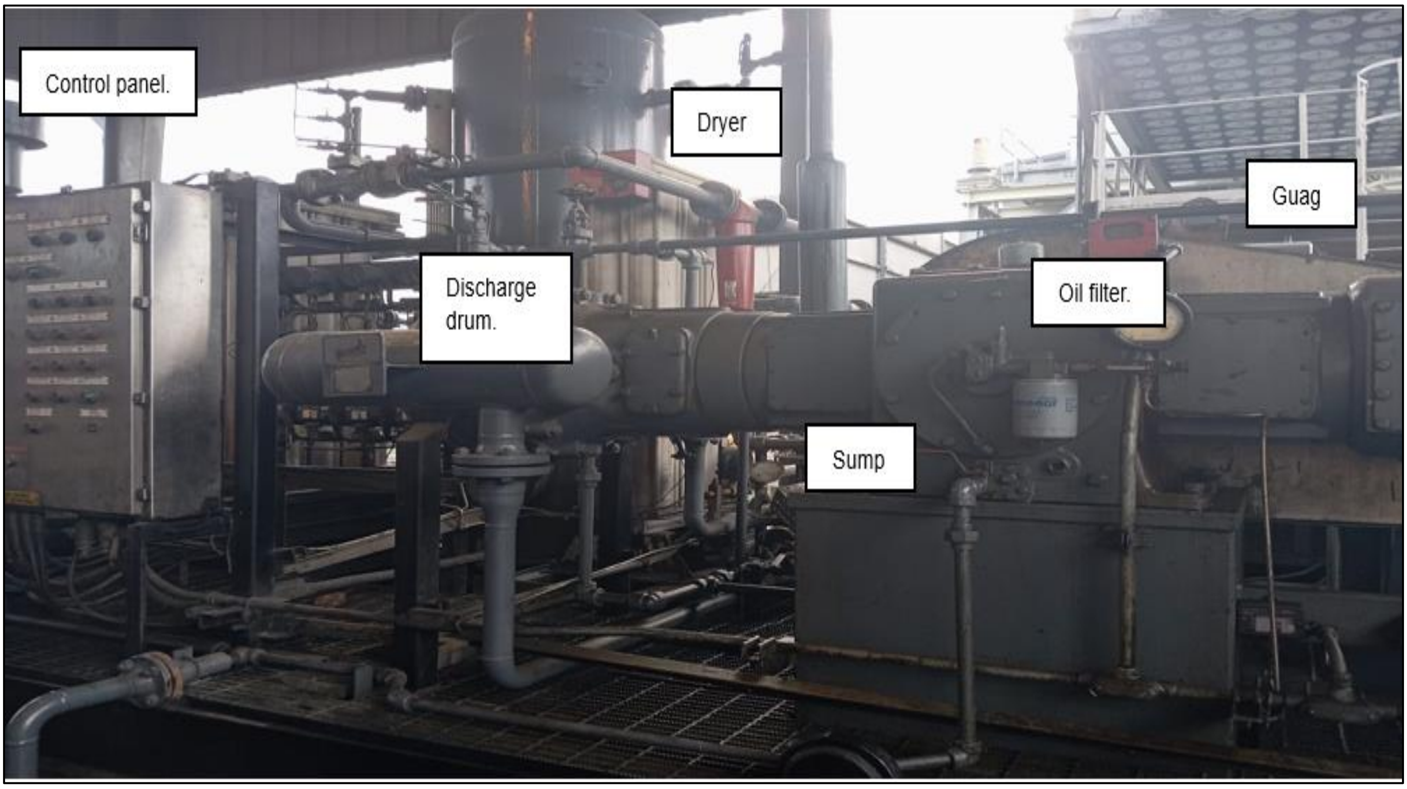

Fig 5: Showing IAC Control Panel, Discharge Drum, oil Sump etc.

For efficiency and reliability of the instrument air compressor, is important that the installation, operations, and maintenance should be done professionally and according to the OEM guide.

- **Installation**: Proper installation of compressors, air dryers, filters, and associated equipment according to manufacturer specifications and industry standards.
- **Operation:** Regular monitoring of compressor operation, including inlet and discharge pressures, temperatures, and power consumption. Ensuring that air quality meets the requirements of instrument and control systems.
- **Maintenance**: Scheduled maintenance activities including:

✓ Routine inspections of compressor components such as belts, filters, valves, and lubrication systems.
✓ Regular replacement of air filters and dryers' desiccant beds to maintain air quality.
✓ Lubrication and coolant checks and changes as per manufacturer recommendations.

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- ✓ Calibration and testing of pressure regulators and control valves.
- ✓ Inspection and maintenance of piping and tubing for leaks or damage.
- ✓ Periodic testing of safety equipment and emergency shutdown systems.

- **Troubleshooting and Repairs**: Prompt identification and rectification of any issues with compressors or associated equipment to minimize downtime and maintain system reliability.
- **Training and Documentation**: Providing adequate training to personnel involved in the operation and maintenance of instrument air compressors. Maintaining comprehensive documentation including operating procedures, maintenance schedules, and equipment manuals.
- **Environmental Considerations**: Proper disposal of compressor lubricants, coolants, and filter elements according to environmental regulations to minimize environmental impact.

III. MOBILE AIR COMPRESSOR

Recognizing the vital role of compressed air, oil and gas facilities often implement redundancy and contingency plans to ensure uninterrupted supply. One such measure is the provision of mobile air compressors as standby equipment in case the primary compressor fails or undergoes maintenance. Here's why this approach is crucial: (John Smith et al, 2022)

- **Minimizing Downtime**: The primary objective of having standby mobile air compressors is to minimize downtime in case of unexpected failures or maintenance requirements of the primary compressor. Rapid deployment of mobile units can help maintain essential operations while repairs or replacements are carried out on the primary system. See figure 6.

Fig 6: Showing Mobile Air Compressor

- **Ensuring Operational Continuity**: Oil and gas facilities operate around the clock, and any interruption in production can have significant financial implications. Having mobile air compressors readily available ensures that essential operations can continue without disruption, safeguarding productivity, and profitability.
- **Enhancing Safety**: Compressed air is often used in critical safety systems such as pneumatic emergency shutdown valves and fire suppression systems. A failure in the compressed air supply can compromise these safety measures, leading to potential hazards. Standby mobile compressors serve as a backup to ensure that safety-critical systems always remain operational.
- **Flexibility and Scalability**: Mobile air compressors offer flexibility and scalability, allowing facilities to adapt to changing operational requirements or temporary expansions. They can be easily transported to different locations within the facility or deployed for specific tasks where compressed air is needed, providing versatility in managing air supply needs.
- **Reducing Risk of Production Loss**: Production loss due to compressed air supply failure can result in significant revenue loss for oil and gas facilities. By investing in standby mobile compressors, facilities can mitigate the risk of production loss associated with compressed air system downtime, thereby protecting their bottom line.

IV. RESULT AND DISCUSION

A. Importance of Instrument Air Compressors

Instrument air compressors serve as the backbone of oil and gas facilities, providing the essential compressed air required for the operation of instrumentation and control systems. These systems are integral to monitoring and regulating various processes within the facility, including pressure, temperature, flow, and level control. Without reliable instrument air compressors, the effectiveness and safety of these systems would be compromised, potentially leading to operational disruptions and safety hazards. (Rachel Adams et al, 2020). Finding the right compressed air treatment based on ISO 8573-1 air quality standard. see table 2.

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Table 2: ISO 8573.1 2010 Air Quality Classes

Class	A			B		C
	SOLID / DIRT Particle size in micron			WATER @ 7 bar / 100 psi Pressure Dewpoint		OIL (including vapor)
	0.10-0.5	05.-1.0	1.0-5.0			
	Max number of particles per m3			° C	° F	Mg /m3
0	As specified			As specified		As specified
1	≤ 20 000	≤ 4	≤ 10	-70	-94	≤ 0.01
2	≤ 400 000	≤ 6000	≤ 100	-40	-40	≤ 0.1
3	–	≤ 90 000	≤ 1000	-20	-4	≤ 1
4	–	–	≤ 10 000	+3	+38	≤ 5
5	–	–	≤ 100 000	+7	+45	> 5
6	–	–	–	+10	+50	–

B. Reliability and Performance

The reliability and performance of instrument air compressors are paramount to the continuous operation of oil and gas facilities. Our study demonstrates that well-maintained compressors exhibit higher reliability, with fewer instances of downtime and maintenance-related issues. Regular maintenance, including filter replacements, lubrication checks, and system inspections, significantly contributes to ensuring the longevity and efficiency of these critical assets. (Emily Parker et al, 2021)

C. Impact on Safety and Environmental Compliance

Instrument air compressors play a crucial role in maintaining safety standards and environmental compliance within oil and gas facilities. By providing clean and dry compressed air, these compressors prevent contamination and corrosion in instrumentation and control systems, thereby reducing the risk of equipment failures and process deviations. Additionally, proper maintenance and monitoring of compressors contribute to minimizing fugitive emissions and environmental impact, aligning with regulatory requirements and industry best practices. (Rachel Adams et al, 2020).

D. Cost Implications and Operational Efficiency

While the initial investment and operational costs associated with instrument air compressors may seem significant, our analysis reveals that these expenses are justified by the considerable benefits they offer in terms of operational efficiency and risk mitigation. The cost of compressor downtime, maintenance, and repair far outweighs the expenses incurred in implementing preventive maintenance programs and ensuring the reliability of these critical assets. Moreover, efficient compressor operation leads to enhanced overall facility performance and productivity, further justifying the investment in reliable instrument air systems. (John Smith et al, 2021)

E. Future Directions and Recommendations

Moving forward, it is imperative for oil and gas facilities to prioritize the proper design, installation, operation, and maintenance of instrument air compressors. This includes investing in advanced monitoring and predictive maintenance technologies to optimize compressor performance and minimize unplanned downtime. Furthermore, continuous training and education of personnel involved in compressor operation and maintenance are essential to ensure adherence to best practices and industry standards. (Sarah Lee et al, 2022)

➢ *Pressure Due Point*

ISO 8573-1:2010 is the primary standard within the ISO 8573 series and establishes the purity classes for compressed air. Therefore, to determine your compressed air treatment needs, you first must know the ISO 8573-1 class for your application. As you can see below, the class requiring the highest air quality is Class 0. In this case, there are no specified contamination levels and no specific pressure dew points, but they have to be below those of Class 1.

It should also be noted that some applications may call for different air quality classes for the different contaminants. For example, the required air quality may be Class 1-2-2, which means it must meet Class 1 regarding solid particles and Class 2 with regard to oil and water. Refer to International Organization for Standardization (ISO). (2010). ISBN: 978-0-580-53715-3

While the contamination levels for solid particles and oil are self-explanatory, the one for water probably requires further clarification for non-experts. In this case, the air quality is determined by the pressure dew point (PDP). The lower the PDP, the less moisture is in your system and the better your ISO 8573-1 class. See table 2.

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V. CONCLUSION

In conclusion, instrument air compressors are undeniably the lifeline of oil and gas facilities, serving as indispensable assets that support safe, reliable, and efficient operations. By recognizing the critical importance of these compressors and implementing proactive strategies for their management and maintenance, oil and gas companies can enhance operational resilience, mitigate risks, and uphold their commitment to safety and environmental stewardship.

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