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Deployment of Smart Pipeline Tie-Ins Technologies on Jazan Abha Pipeline Project (JAPP)

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Abstract

Pipeline technologies have significantly improved project execution by providing smart tools to address constraint's and improve the project cost and schedule. The Jazan Abha Pipeline Project (JAPL-2) aimed to develop oil supplies to the southern region of Saudi Arabia by constructing and upgrading pipelines over more than 90 km of challenging terrain. This paper discusses the state-of-the-art advancements utilized to complete joint activities in the JAPL-2 project connected with the existing JAPL-1 pipeline. Key challenges included creating connections in remote areas and steep inclines, requiring precise regulation to minimize closure times and avoid extensive downtime. The approach incorporated advancements from Remote Techno Plug (RTP) and BISEP, along with engineered supports, to provide robust pipeline separation and reduced downtime. These developments facilitated double block and bleed isolation, remote-controlled operations, and consistent hot tapping, ensuring safe and efficient transitions. The implementation framework included two four-day closure periods to connect tie-ins at Booster Stations (BS1) and (BS2). This approach minimized operational interruptions, enhanced safety by reducing manual task loads, and improved resource usage. The team obtained necessary approvals, conducted an in-depth review, and implemented the plan. High-level advancements in key separation and integration were important in overcoming project challenges, resulting in reduced downtime, improved safety, and consistent standard operations. The outcome concluded a successful story by accomplishing the required job safely and proving the team's effort in strategizing the execution by selecting the most appropriate and advanced technologies.

Keywords: *Pipeline technologies, smart pipeline tie-in, pipeline shutdowns, challenges, remote TechnoPlug, positive isolation, BISEP.*

1. Introduction

The Jazan-Abha Pipeline Project (JAPL-2) aims to meet the Kingdom of Saudi Arabia’s demand for refined products in the southern region by constructing a new 90 km pipeline from Jazan to Booster Station 1 (BS1) and upgrading the pipeline sections downstream of BS1 and Booster Station 2 (BS2) by 10 km and 1 km respectively. These pipelines cross remote areas and steep mountainous terrain, presenting significant challenges. The JAPL-2 project is designed to address the Kingdom's expanding need for refined products in the Jazan, Abha, and Najran regions. It aims to improve the existing pipeline system's dependability and efficiency, increase safety, and lower transportation costs (Akrasi et al., 2021). The goal is to expand the supply of Ultra Low Sulphur Diesel (ULSD), Premium Gasoline 91 (PG-91), Premium Gasoline 95 (PG-95), and Kerosene to satisfy the estimated demand of 155 MBD by 2040. The project also includes expanding the Abha Bulk Plant, adding truck loading facilities, and modifying the control system software at SSSP Abha Receiving Site-6. The company's vision is to be a market leader in the energy sector, offering high-quality products and services while upholding safety, integrity, and social responsibility. The organization employs a diverse workforce and fosters a culture of innovation and continual improvement (Arishi, 1991). The circumstances necessitate strategic execution, including the exploration of several technologies to complete the project work safely and efficiently. Subject matter experts (SMEs) were also required to identify the constraints and provide appropriate, robust technical solutions with optimal outcomes fit for purpose.

2. Background

The Jazan-Abha Pipeline Project (JAPL-2) is one of the major infrastructure projects designed to meet the growing energy needs in the southern region of Saudi Arabia. This project involves the development of a new 90 km pipeline from Jazan to Booster Station 1 (BS1) and upgrading the downstream areas of BS1 and Booster Station 2 (BS2) by 10 km and 1 km, respectively. The new pipeline and upgrades are important for reducing dependency on trucking and maritime exports, resulting in significant cost savings and increased safety and reliability. The pipeline moves through challenging terrains, including extensive remote areas and steep slopes, requiring careful planning and implementation (Akrasi et al., 2021). The organization anticipates significant changes to the current system in both BS1 and BS2 to integrate the new pipeline with the existing infrastructure. At BS1, the adjustments include four welded joints and three sandblasted joints, while BS2 requires eight bolted joints. These modifications necessitate the separation of pipeline sections upstream and downstream of the connection area. The project development also includes discharging pipeline material, flushing pipelines, dismantling existing structures, installing new spool pipes, performing hot work, significant bolting activities, and re-emergence support of new lines. This complex series of tasks requires precise coordination with the primary goal being to minimize downtime and ensure safety. Traditional connection execution strategies, such as slow closure and product depletion, are considered ineffective and insufficient (Sevillano et al., 2021). Instead, state-of-the-art advancements have been explored to improve execution. Remote Techno Plug (RTP) and BISEP, combined with engineered clamps, were selected for their ability to reliably isolate lines and eliminate the need for long material delivery times.

These innovations were made possible by completing connections during two four-day closure windows, ensuring the project's progress and safety (Hendawy et al., 2023). The successful execution of the JAPL-2 project is based on innovative pipeline improvements that overcome critical and technical challenges, ultimately ensuring the smooth delivery of the system.

3. The Problem Identified

A critical challenge of the Jazan-Abha Pipeline Project (JAPL-2) was making connections with the existing JAPL-1 pipeline, especially in remote and geographically challenging regions. The need to establish new pipeline areas downstream of Booster Stations 1 and 2 (BS1 and BS2) required precise separation and transformation practices in confined and hard-to-reach spaces (Kindree et al., 2022). At BS1, the connections included four welded joints and three shot-welded joints, while BS2 required eight shot-welded joints. These modifications necessitated the complete shutdown of the pipeline and facility, presenting significant computational challenges. Moreover, the weaknesses of nearby division points further complicated the issue. For instance, the nearest division points for the downstream connection of BS1 are 10 km upstream and 20 km downstream, requiring the depletion of 30 km of pipeline sections (Rausch et al., 2023). Additionally, the downstream tie-in of BS2 faced the issue of separation, with the nearest upstream control point being 2 km away and the downstream point being 10 km away. These complex and daunting conditions are time-consuming and present environmental and safety risks. Traditional strategies such as deferred terminations and inevitable material consumption were viewed as inefficient and impractical. Significant amounts of materials would be drained, and delayed terminations would cause immense operational interruptions and inflated costs. Additionally, traditional cutting and welding techniques are inadequate due to the complexity of accessing and modifying pipelines in steep and remote areas. Therefore, innovative plans were required to meet these demands. The challenge was to find a procedure that minimizes downtime, reduces material waste, ensures safety, and delivers effective results from the joints.

4. The Design Solution

To address the requirements identified, a comprehensive plan was developed enhancing the network process. The primary advancements chosen were Remote TechnoPlug (RTP) and BISEP combined with engineered clamps. Remote Techno Plug (RTP) is a detachable remote-controlled device that offers double block and bleed isolation and controlled regulation. Its control system provides versatility, eliminating the need for highly adjusted connectors or 'pig-trap doors.' This tool ensures precise positioning and close monitoring, important for the exact separation required within the organization (Muthalaly et al., 2023). Locally accessible pressure drive systems facilitate important updates and controls, improving safety and efficiency in critical operations. RTP is normally deployed with a remote-control system comprising a control module pigged in with the plug that sets and monitors the plug under instructions communicated through the pipe wall with External Low Frequency (ELF) communications. The remote-control module provides a very high-level robust system for safety-critical activities. The tool is controlled and monitored via seven hydraulic circuits: Hydraulic Set pressure, Hydraulic Unset, Annulus Monitor, Downstream Monitor (Head), Upstream Monitor (Tail), Hydraulic Supply Pressure, and Internal Pressure.

BISEP development provides double security against obstruction and channel disconnection through a novel hot-tapping intervention technique (BISEP Line Plugging, 2024).

This eliminates the need for extra venting or hydraulic activation. BISEP's strong double seals enable tight separation of strain and pressure pipes, offering significant security benefits over traditional line stop upgrades.

Fig 1: *TecnoPlug & BISEP - Deployment in Jazan Abha Pipeline Projects*

BISEP™ is the Double Block and Bleed isolation tool developed and patented by STATS Group. It uses TecnoPlug seals mounted on a spherical head to provide dual barrier isolation. The BISEP™ offers all the dual seal advantages of a TecnoPlug but with some additional features (BISEP Line Plugging, 2024). The pressure head primary seal, annulus ring, and secondary seal operate in a similar manner to the TecnoPlug. The BISEP is installed through a hot tap penetration, so instead of the taper locks, two solid clevis arms restrain the BISEP, each of which can resist the full test pressure (HOT TAP CLAMP, 2024). It also has a secondary leak-tight pressure head mounted to the rear of the secondary seal and has a permanent hydraulic connection through the launcher which allows continuous safe venting of any primary seal bypass. The use of clamps designed for hot tapping allows for the connection of new branch lines to the existing system without the need for welding. These clamps help control the hot-running flanged tee branch using direct conductors without disrupting the innovative process. This methodology enabled the BISEP plunging tool and plug to be deployed, further streamlining the connection process.

TecnoPlug™ - is derived from the dual seal tethered isolation plug. The basic concept is for two compression seals mounted in series outboard of a taper lock array. TecnoPlug Isolation Tool which provides fail-safe double block and monitor isolation for high pressure pipelines. The dual seal configuration of the TecnoPlug provides an annulus void which can be pressure tested to verify both seals are leak tight before work is carried out. Both seals are leak tested above the maximum potential isolation pressure. Once the seal integrity is achieved, the annulus is vented to ambient to create a zero-energy zone, providing effective double block and monitor isolation.

The TecnoPlug™ is normally deployed with a remote-control system which comprises a control module pigged in with the plug that sets and monitors the plug under instructions communicated through the pipe wall with External Low Frequency (ELF) communications. The remote-control module provides a very high-level robust system for safety critical activities. The tool is controlled and monitored via seven hydraulic circuits mainly Hydraulic Set pressure, Hydraulic Unset, Annulus Monitor, Downstream Monitor (Head), Upstream Monitor (Tail), Hydraulic Supply Pressure and Internal Pressure.

The isolation plug is hydraulically activated by the control module on deployment. This causes the internally mounted hydraulic cylinder in the TecnoPlug™ to contract so setting the locks and seals to create the initial barrier. Once the plug is confirmed as set, the pressure inboard (portion of the pipe to be isolated) is vented generating a pressure differential across the plug module. As the pressure differential is applied, the trapped fluid in the annulus between the seals is compressed due to the seal compression. The other effect is that the hydraulic pressure in the actuation system drops. The remaining hydraulic set pressure once the pipe is fully vented is locked in by pilot operated check valves to ensure it is maintained, even with loss of power in the control module.

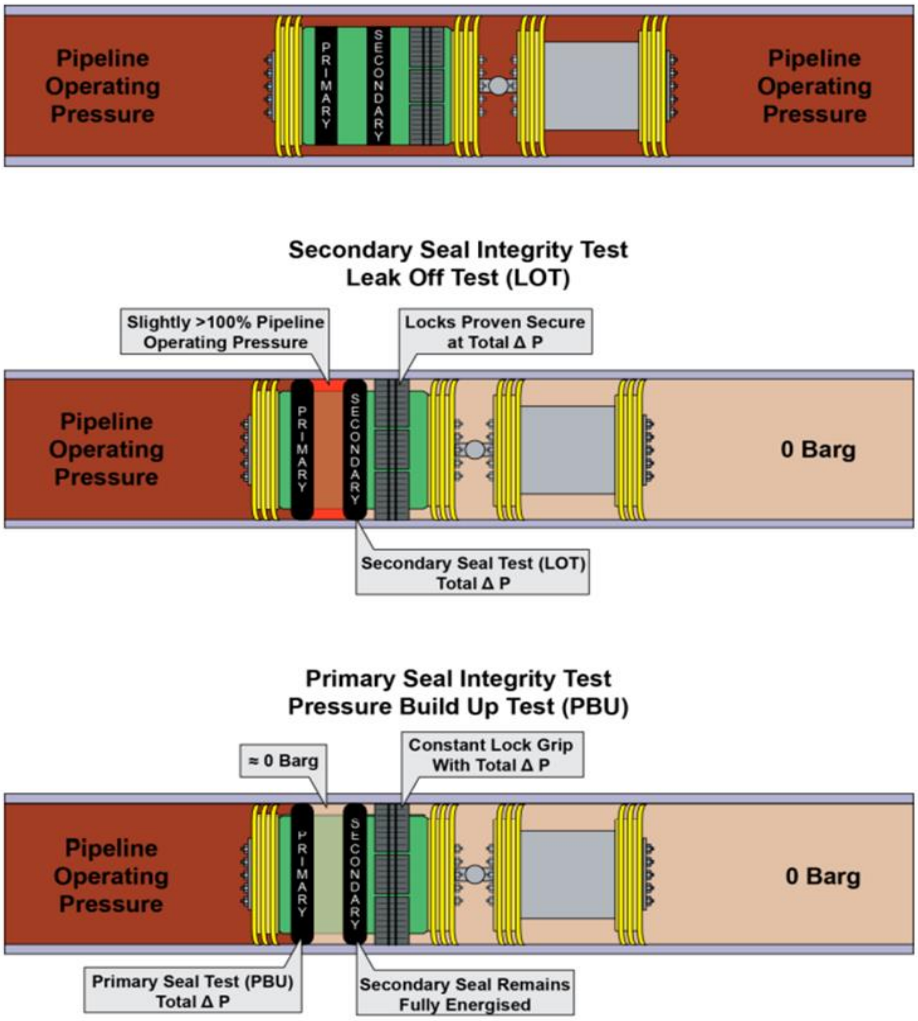

Fig 2: *TecnoPlug Seal Verification Cycle*

5. Implementation

The execution phase was meticulously planned to leverage the selected advancements ensuring minimal disruption and maximum efficiency. The process began with securing all necessary documentation and approvals, including alternative action plans, execution plans, alignment packs, risk assessments, Job Safety Analysis (JSAs), fitting plans, and point-to-point planning (Manzano et al., 2023). The implementation was divided into two primary shutdown periods, each lasting four days, to make significant changes and tie-ins at Booster Stations 1 and 2 (BS1 and BS2). The framework included hot tapping through planned clamps at designated connection areas. For BS1, hot tapping was initiated 10 km downstream of the connection area to establish the foundation of BISEP.

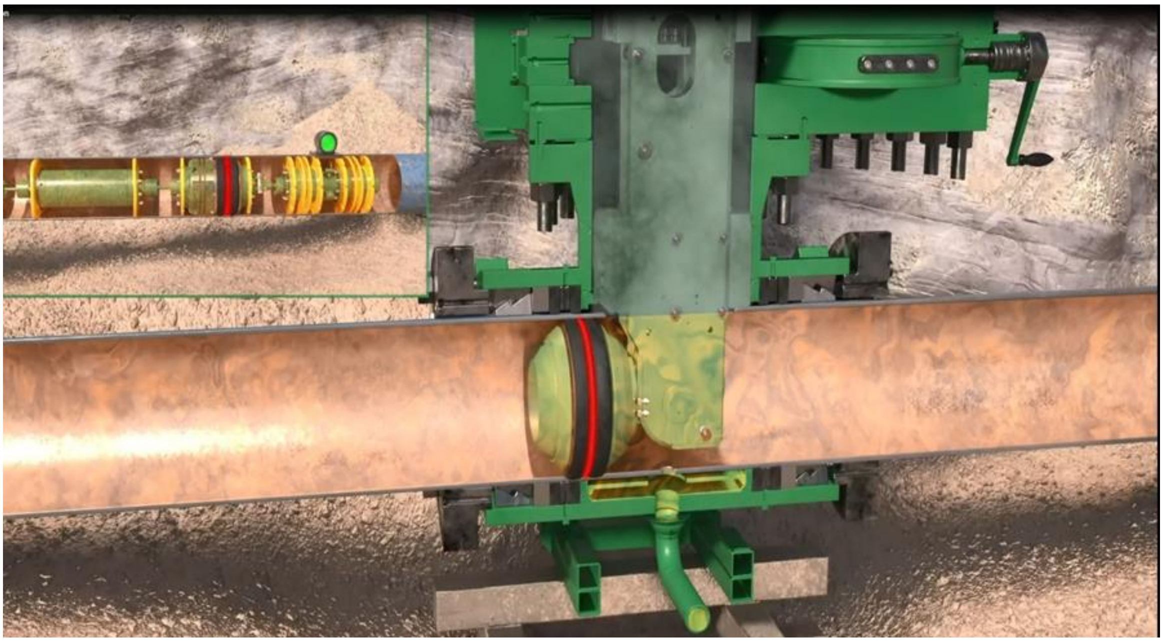

Fig 3: *BISEP & TechnoPlug in Position*

Fig 4: *Typical Full Stack arrangement on Jazan Abha Pipeline for Execution*

BISEP provided upstream regulation while the Remote Techno Plug (RTP) was used for downstream isolation. Booster Station 1 (BS1): Prior to the shutdown, the RTP was sent from BS1 and navigated the connection area through the channel launcher. The shutdown began once the RTP arrived at its assigned location, approximately 5 meters downstream of the connection area. The separation components were assessed and approved, allowing connection activities to commence in both BS1 and the downstream connection area. Within the scheduled four-day period, all necessary modifications to BS1 and the downstream network were completed. The top-off system used the remaining components in the replaced pipeline section. The material was pumped from JAPL1 to JAPL2 using a multi-purpose pump and frac tank. At the connection area, a short scrubber starter was introduced and the scrubber load was pushed through with nitrogen to agitate the frac tank contents before bringing it into the new pipeline. After the line was filled, JAPL1 was returned . Booster Station

Booster Station 2 (BS2): An identical methodology was used to shut down BS2 with minor adjustments to meet site-specific requirements. The key challenge at BS2 was the lack of a platform at the transmission station which required RTP setup. RTP initiated the well point and the connection processes proceeded as planned.

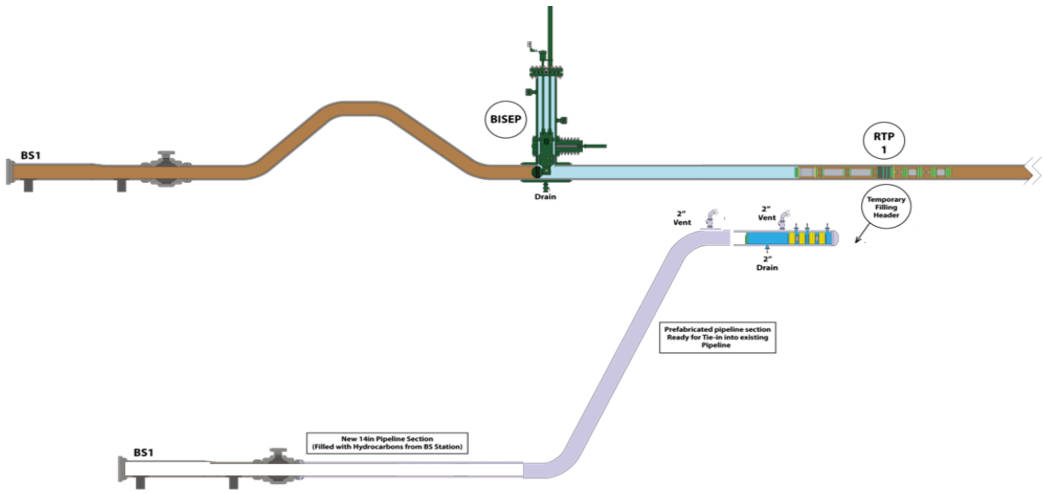

Fig 5: *Isolation mechanisms with RTP & BISEP in position*

Downstream isolation was achieved using RTP while upstream separation was provided by BISEP. The implementation used modern and complex enhancements to complete connections within the designated shutdown windows, ensuring safety and efficiency. Hot Tapping and Mechanical Clamps: The BISEP and hot tapping machines used mechanical hot tapping clamps to facilitate the connection of new branch pipework to existing infrastructure without the need for any welding. Hot tap clamps are routinely used to provide a flanged tee branch to enable hot tapping into an existing pipeline while under pressure with no interruption to production. The fittings can also be utilized as an access point to deploy a double block and bleed BISEP line plugging tool (Alsahafi et al., 2023). This was used instead of welding a pad to install the hot-tapping machine in the line. Design Implementation Stage: The Design Solution Implementation phase turned the theoretical design into a practical reality, including the building of a new pipeline (JAPL-2) and the upgrade of existing pipeline portions. The pipeline, which can transport refined goods at a maximum throughput of 80 MBD, is outfitted with sophisticated automation and instrumentation equipment. The project also included upgrading existing pipeline sections, installing booster pumps, shipper pumps, and mainline isolation valve stations, expanding the Abha Bulk Plant, and modifying control system software at SSSP Abha Receiving Site-6 to ensure seamless integration and efficient transportation of refined products (Alsahafi et al., 2023).

6. The Advantage of Implemented Design

The Jazan Abha Pipeline Project aims to increase capacity to 80 MBD addressing the region's growing demand for refined products. The design includes advanced automation and instrumentation technologies to reduce accidents and ensure safe, reliable operation. The pipeline and infrastructure are intended to reduce the need for intermediate storage, lower transportation costs, and improve supply chain efficiency. The design incorporates advanced automation and instrumentation technologies that enhance operational safety and reliability (Collarini et al., 2022). These technologies reduce the risk of accidents by providing real-time monitoring and control, ensuring safe operations under various conditions. The pipeline's automated systems allow for precise control of flow rates and pressures, minimizing the potential for human error and ensuring consistent product delivery. The improved pipeline infrastructure reduces the need for intermediate storage facilities. This reduction lowers operational costs and minimizes the environmental footprint of the pipeline system. By streamlining the transportation process, the project enhances supply chain efficiency, ensuring that refined products are delivered more quickly and reliably to their destinations. The design reduces environmental impacts by lowering the visible impact of above-ground infrastructure (Kaiser, 2020). The use of advanced materials and construction techniques minimizes the ecological footprint of the pipeline. Additionally, the pipeline's redundant architecture and advanced control systems ensure continuous supply, reducing the likelihood of disruptions that could lead to environmental harm. The redundant architecture and advanced control systems of the pipeline ensure continuous supply, reducing downtime and delivering a consistent source of refined products (Khalturin et al., 2023).

7. Ways the Design Adversely Supported the Case

Despite the advanced capabilities of Remote Techno Plug (RTP) and BISEP, the deployment of these technologies required meticulous planning and execution. Any deviation or failure in the operation of these technologies could lead to significant project delays and potential safety hazards. For instance, the precise alignment and setting of RTP and BISEP are important; any misalignment could compromise the integrity of the pipeline isolation, leading to leaks or failures (Kase et al., 2022). While the use of RTP and BISEP aimed to minimize operational interruptions, the actual execution involved temporary shutdowns. These shutdowns, although planned and executed within a four-day window, still caused some disruption to the ongoing operations. The need for precise coordination and synchronization of activities meant that any unexpected issues could extend the shutdown period, affecting the project timeline and operational continuity. The implementation of RTP and BISEP required specialized equipment and trained personnel, which necessitated significant resource allocation.

Fig 6: *Jazan Team with RTP & BISEP in position for Execution*

The procurement and deployment of these advanced tools involved substantial costs, and the need for highly skilled operators added to the project expenses. This allocation of resources could have been challenging in a resource-constrained environment, potentially affecting other critical areas of the project. Although the advanced technologies aimed to reduce environmental impacts and enhance safety, the deployment itself carried inherent risks. The hot tapping and plugging operations involved handling hazardous materials and operating in confined spaces, which posed potential environmental and safety hazards. Any failure in the isolation or containment measures could lead to spills or exposure to hazardous substances, necessitating stringent safety protocols and contingency plans. The integration of RTP and BISEP technologies added a layer of complexity to the project execution. The need for precise planning, coordination, and execution required a high level of expertise and meticulous attention to detail. This complexity increased the risk of errors or oversights, which could have significant repercussions on the project outcomes.

8. Recommendations

The effective use of Remote Techno Plug (RTP) and BISEP demonstrated their capabilities in ensuring safe and precise pipeline operations. Future projects should consider these tools to reduce downtime, enhance safety, and improve work efficiency. Clamps designed for hot tapping reduce the need for welding, lower fire risks, and speed up the process. This approach ensures continuous work and mitigates environmental risks. The two four-day shutdown periods in this project highlight the importance of careful planning. Future projects should apply similar strategies to minimize disruptions and improve resource use. Detailed schedules, risk assessments, and emergency plans should be part of project management to handle unforeseen challenges effectively. Reducing environmental impacts through resource conservation is important. Advances in isolation and hot tapping techniques help with environmental management. Projects in sensitive areas should especially focus on these best practices to minimize ecological footprints and ensure sustainable operations. The enhanced security provided by RTP and BISEP highlights the importance of strong safety protocols. Future projects should integrate these advanced technologies to minimize risks and ensure the safety of professionals. Continuous inspections and ongoing communication should be maintained to meet high safety standards. The design's attention to scalability and maintainability highlights the importance of planning infrastructure with future expansion and upgrades in mind.

9. Conclusion

The successful completion of the Jazan Abha Pipeline Project (JAPP) highlights the transformative potential of integrating advanced pipeline technologies in large-scale infrastructure projects. The application of Remote TechnoPlug (RTP) and BISEP, combined with specially engineered mechanical clamps, proved to be important in overcoming the project's numerous technical challenges. These technologies enabled precise, reliable isolation and seamless integration of new pipeline segments with the existing network, significantly reducing downtime and enhancing overall operational safety. The strategic use of RTP and BISEP facilitated a safe and efficient execution process by minimizing the need for extensive shutdown periods and reducing the volume of product loss. This approach not only streamlined the project timeline but also optimized resource utilization and mitigated environmental impacts associated with traditional pipeline modification techniques. By leveraging cutting-edge tools and methodologies, the JAPP set a new benchmark for future pipeline projects, demonstrating that innovative solutions can effectively address complex challenges and drive substantial improvements in project outcomes. The Jazan Abha Pipeline Project serves as a model for deploying advanced pipeline technologies to achieve safe, efficient, and cost-effective infrastructure development. As the demand for energy infrastructure continues to grow, the lessons learned from JAPP will be invaluable in guiding future projects toward achieving similar success through the adoption of innovative technologies and strategic project management practices.

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