

PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA
Ministry of Higher Education and Scientific Research

N° Series /2026

Kasdi Merbah Ouargla University



Faculty of Hydrocarbons Renewable Energy and Science of the Earth and the Universe

Drilling and MCP Department

DESSERTATION

To obtain the Master's degree

Sector: Petroleum Engineering

Option: Drilling

Presented by:

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- TITTLE-

**Effective Application of Tubing Punch Technology for Restoring
Production in a Highly Deviated Gas Well (HYR-03) With a Stuck Plug in
the Timimoun Field.**

Publicly defended on: .../.../2026

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College year: 2025/2026



Thanks

First of all, we thank Almighty God for giving us the courage, health, and determination to successfully complete this work.

We would like to express our sincere appreciation and gratitude to our supervisor, Mr. Bilal Fenazi, for his valuable guidance, continuous support, and constructive advice throughout the preparation of this thesis. His experience, patience, and encouragement were of great importance in accomplishing this work.

We also extend our sincere thanks to the members of the jury for accepting to examine this thesis and for the time and effort devoted to evaluating our work and providing valuable remarks and recommendations.

Special thanks are addressed to all the staff and engineers who contributed to this study and shared their knowledge and experience with us during the realization of this project.

We are deeply grateful to our parents and families for their unconditional support, encouragement, and sacrifices throughout our academic journey.

Finally, we would like to thank all those who contributed directly or indirectly to the completion of this work



Dedication

I dedicate this modest work above all:

To my dear parents who have always pushed and motivated me in my studies. This work, therefore, represents the culmination of the support and encouragement they gave me throughout my schooling.

May they be thanked for this too-modest dedication.

It is a moment of pleasure to dedicate this work,

To my dear brother and my sister,

To all my family members.

Also, I dedicate this work to all my dear friends.

To all teachers of hydrocarbons.

In the end, I warmly dedicate this dissertation to my trinomial

DJEBABRIA ALLA and ABDERAOUF BOUCHECHE

Ramzi Khadiche

Dedication

I dedicate my work to my dear mother; to whom I wish a very long life, full of joy, happiness, and prosperity.

To my father, may GOD the Almighty have their souls and welcome them into his vast paradise;

My sisters, brothers, and all the members of the “DJEBABRIA” families

To all teachers of hydrocarbons.

In the end, I warmly dedicate this dissertation to my trinomial

KHADICHE RAMZI and ABDERAOUF BOUCHECHE

Without forgetting the friends and comrades with whom I had shared unforgettable moments.

Alla Djbabria

Dedication

I dedicate this modest work first and foremost to my beloved parents, whose continuous support, encouragement, and sacrifices have always motivated me throughout my studies. This achievement is the result of their trust, guidance, and unwavering belief in me. No words can truly express my gratitude and appreciation for everything they have done for me.

I also all members of my family for their constant encouragement and support.

Special dedication goes to all my dear friends who stood by me during this academic journey.

I would also like to dedicate this work to all the teachers and professors of the Hydrocarbons Department for their valuable knowledge and guidance.

Finally, I warmly dedicate this dissertation to my trinomial partners:

DJEBABRIA ALLA and KHADICHE RAMZI

Abderaouf Boucheche

Abstract

ABSTRACT

This dissertation presents the successful application of Tubing Punch Technology to restore production in the highly deviated gas well HYR-03 in the Timimoun Field, southwestern Algeria. Production was hindered by a stuck plug and completion restrictions that prevented conventional intervention methods from achieving the desired results.

The study reviews the geological characteristics of the Timimoun Basin and discusses modern well intervention technologies, particularly Radial Cutting Torch (RCT) and Tubing Punch systems. A detailed case study of HYR-03 demonstrates how an electric wireline tubing punch was used to establish communication between the tubing and annulus below a permanent packer, enabling gas production without major tubing retrieval operations. The operation successfully restored production to approximately 250–300 KSm³/day, close to the well's initial rate. The results confirm that Tubing Punch Technology is a safe, efficient, and cost-effective solution for overcoming complex production challenges in highly deviated gas wells.

Keywords: Tubing Punch Technology, RCT, Production Restoration, Highly Deviated Gas Well,

RÉSUMÉ

Ce mémoire présente l'application de la technologie de Tubing Punch pour restaurer la production du puits gazier fortement dévié HYR-03 situé dans le champ de Timimoun, au sud-ouest de l'Algérie. La production était limitée par un bouchon coincé et des restrictions de complétion qui empêchaient les méthodes conventionnelles d'intervention de réussir.

L'étude décrit les caractéristiques géologiques du bassin de Timimoun ainsi que les technologies modernes d'intervention sur puits, notamment le Radial Cutting Torch (RCT) et le Tubing Punch. L'application réalisée sur le puits HYR-03 a permis de créer une communication entre le tubing et l'annulaire sous un packer permanent à l'aide d'un système par câble électrique, sans récupération importante du tubing. L'opération a permis de rétablir une production de l'ordre de 250 à 300 KSm³/jour, proche du débit initial du puits. Les résultats démontrent que cette technologie constitue une solution sûre, efficace et économique pour la restauration de la production.

Mots-clés : Tubing Punch, RCT, Restauration de production, Puits fortement dévié.

المخلص

تتناول هذه المذكرة استخدام تقنية تنقيب الأنابيب (Tubing Punch) لاستعادة الإنتاج في البئر الغازي عالي الانحراف HYR-03 بحقل تيميمون جنوب غرب الجزائر. وقد تعطل الإنتاج بسبب وجود سدادة عالقة ومشكلات في الإكمال حالت دون نجاح طرق التدخل التقليدية. تعرض الدراسة الخصائص الجيولوجية لحوض تيميمون وتقنيات التدخل الحديثة في الآبار، خاصة أنظمة القطع الشعاعي (RCT) وتقنية تنقيب الأنابيب. كما توضح الدراسة التطبيقية كيفية استخدام نظام تنقيب بواسطة السلك الكهربائي لإنشاء تواصل بين أنبوب الإنتاج والحيز الحلقي أسفل الـ Packer الدائم، مما سمح باستعادة الإنتاج دون الحاجة إلى سحب كبير للأنابيب. أسفرت العملية عن استعادة إنتاج يتراوح بين 250 و 300 ألف متر مكعب قياسي يومياً من الغاز، وهو قريب من معدل الإنتاج الأصلي للبئر. وتؤكد النتائج أن تقنية Tubing Punch تمثل حلاً آمناً وفعالاً ومنخفض التكلفة لمعالجة مشكلات الإنتاج المعقدة في الآبار الغازية عالية الانحراف.

الكلمات المفتاحية: تقنية تنقيب الأنابيب، RCT ، استعادة الإنتاج، بئر غازي عالي الانحراف.

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GENERAL INTRODUCTION

GENERAL INTRODUCTION

The oil and gas industry continuously faces technical and operational challenges related to maintaining well integrity and sustaining hydrocarbon production. As reservoirs mature and wells become increasingly complex, advanced well intervention technologies have become essential for restoring production, minimizing operational costs, and extending well life. In highly deviated and horizontal gas wells, conventional intervention methods such as fishing, milling, or full tubing retrieval may become technically difficult, economically expensive, and associated with significant operational risks.

Among the modern intervention techniques, tubing punch technology has emerged as an effective and practical solution for creating communication between the tubing and annulus without removing the completion string. This technology is particularly useful in wells affected by stuck plugs, tubing restrictions, or pressure isolation problems, where conventional workover operations may not be feasible. In addition, Radial Cutting Torch (RCT) systems provide efficient non-explosive pipe-cutting solutions that improve operational safety and reduce intervention time.

The Timimoun gas field, located in southwestern Algeria within the Gourara–Timimoun Basin, represents one of the important gas developments in the Algerian Sahara. The field mainly produces dry gas from Lower Devonian sandstone reservoirs characterized by low permeability and complex geological conditions. Due to the strategic importance of gas production from this field, maintaining well productivity and ensuring reliable intervention solutions are essential for operational continuity.

The HYR-03 well experienced several operational problems during its production history, including completion restrictions and the presence of a stuck plug that prevented normal communication between the reservoir and the production tubing. Conventional intervention attempts, including tubing cutting and retrieval operations, faced multiple technical difficulties because of the highly deviated nature of the well and the downhole completion configuration. Consequently, an alternative solution was required to restore production while minimizing operational risks and costs.

This dissertation focuses on the application of tubing punch technology as an optimized intervention method to restore production in the HYR-03 well. The study includes a geological overview of the Timimoun Field, a detailed presentation of modern well intervention technologies, and a practical field case study describing the planning, execution, and evaluation of the tubing punch operation.

The main objectives of this work are:

- To present the geological and reservoir characteristics of the Timimoun gas field.
- To explain the principles and operational procedures of tubing punch and RCT technologies.
- To analyze the operational challenges encountered in well HYR-03.

GENERAL INTRODUCTION

- To evaluate the effectiveness of tubing punch technology in restoring production.
- To demonstrate the technical and economic advantages of rigless intervention solutions in highly deviated gas wells.

This dissertation is divided into three main chapters. The first chapter presents the geographical and geological overview of the Timimoun Field and its reservoir characteristics. The second chapter discusses well intervention technologies, focusing on pipe-cutting systems and tubing punch operations. The third chapter presents the HYR-03 field case study, including the operational history, intervention procedures, technical evaluations, and final production results after the tubing punch operation.

CHAPTER I:

Geographic & Geological Overview of the Timimoun Field

CHAPTER I: Geographic & Geological Overview of the Timimoun Field

1. Introduction:

The Timimoun gas field is one of the major natural gas developments located in southwestern Algeria within the Gourara–Timimoun Basin, which forms part of the Western Saharan Platform. The field is situated between the towns of Timimoun and Adrar in the Adrar Province. This region lies in the central Sahara Desert and is characterized by arid climatic conditions, extensive sand dunes, and limited infrastructure. Despite its remote location, the Timimoun Field represents an important component of Algeria's hydrocarbon resources and contributes significantly to the country's natural gas production and transportation network through the regional GR5 pipeline system. Geologically, the Timimoun Basin is composed mainly of Paleozoic sedimentary formations deposited above a Precambrian crystalline basement. The basin contains thick sequences of sandstones, shales, and siltstones that were formed in marine and continental depositional environments. The main gas-producing reservoirs are Lower Devonian sandstones, particularly those of the Emsian, Pragian, and Lochkovian ages. These reservoirs are associated with organic-rich Silurian shales, which act as the principal source rocks and regional seals within the petroleum system. The geological structure of the basin was strongly influenced by regional tectonic events related to the movement of the African and Eurasian plates, resulting in structural traps, faults, and unconformities favorable for hydrocarbon accumulation. Exploration activities in the Timimoun area intensified during the early 2000s through seismic surveys and exploratory drilling programs, which confirmed the presence of commercially significant gas reserves. The field was later developed through a partnership between Sonatrach, TotalEnergies, and CEPSA, with commercial gas production officially starting in 2018. The produced gas consists mainly of dry methane with moderate amounts of carbon dioxide. Although the reservoirs generally have low porosity and permeability, natural fracturing and localized high-quality zones improve reservoir productivity. Today, the Timimoun Field is considered an important example of successful gas development in the Algerian Sahara and plays a strategic role in supporting Algeria's energy industry and gas export capacity.

2. Geographical Situation of the Timimoun Field (Algeria)

The Timimoun gas field is located in the Southwest of the Algerian Sahara, within the Gourara Basin, a large sedimentary basin of the Western Saharan platform. The basin lies roughly between 1°W and 3°E longitude and 24°N and 32°N latitude, covering over 121,000 km² in the central Sahara Desert of Algeria. This region is situated about 900 km south-southwest of Algiers and forms part of the extensive desert interior of the country.

The gas field is positioned in Blocks 325a and 329 of the Timimoun Basin and is part of several gas discoveries and developments in this area. It lies approximately between the towns of Timimoun and Adrar in the wilaya (province) of Adrar in southern Algeria. The field occupies a remote, onshore desert location characterized by vast sand seas and minimal infrastructure, with the closest built-up area (Oughroud) some 120 km away and without direct paved road access.

CHAPTER I: Geographic & Geological Overview of the Timimoun Field

The field's location within the Gourara Basin places it among Algeria's major southwestern hydrocarbon provinces, where gas from the Timimoun project is transported via regional pipelines for processing and export. ^[1]

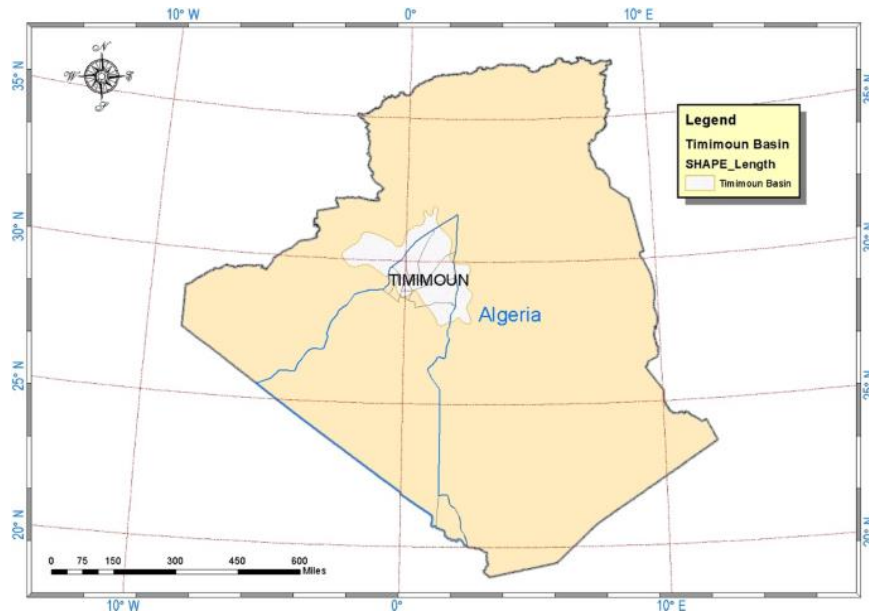


Figure I.1: Location map of Timimoun-Algeria. ^[1]

3. Geological Situation of the Timimoun Field

The Timimoun gas field is located within the Gourara–Timimoun Basin, part of the Western Saharan continental platform in southwestern Algeria. The basin is characterized by a complex geological structure shaped by regional tectonic movements and bounded by several structural highs and adjacent basins. The field is situated on the Tademaït Plateau, at the southern margin of the Grand Erg Occidental in the Sahara Desert, approximately 700–750 km southwest of Hassi Messaoud. ^[2]

The Timimoun Basin is generally bounded by:

- East: Idjerane–M'zab structural high (separates it from the Ahnet/M'zab areas)
- North: Oued Namous and Djofra uplifts (vaults)
- West: Beni Abbès Saddle and Azzène structural high
- South: Northern margin of the Hoggar (Tuareg Shield) basement outcrops

CHAPTER I: Geographic & Geological Overview of the Timimoun Field

4. History of the Timimoun Field

The Timimoun gas field project is part of the broader development of Algeria's southwestern hydrocarbon resources. Exploration activities in the Gourara–Timimoun Basin began in the early 2000s, with seismic surveys and drilling confirming the presence of commercially significant Paleozoic gas reservoirs. In December 2017, Sonatrach, in partnership with TotalEnergies and CEPESA, signed a new concession agreement to accelerate the field's development, which included the drilling of up to 37 production wells and construction of processing facilities tied to the regional GR5 pipeline system to transport gas from the field to the national grid.

Development of the field continued into the late 2010s, and after several years of construction and infrastructure works, commercial gas production commenced in March 2018. The production complex has an estimated plateau capacity of about 5 million cubic meters of natural gas per day (approximately 1.82 billion cubic meters per year), with gas produced from multiple wells connected to the processing plant and transported via the pipeline to the Hassi R'mel treatment center.

The start-up of Timimoun marked a new stage in the operational history of the operators, representing an expansion of Sonatrach's domestic production base and a continuation of Total's exploration and production activities in Algeria that date back to the 1950s. The field also represented the first commercial gas production for CEPESA in the country. ^{[3] [4]}

5. Structural Framework:

Geologically, this area is located within the Timimoun Basin, where the existence of a gas petroleum system has been widely demonstrated. All hydrocarbon targets in the area are located within the Paleozoic formations (Ordovician to Upper Devonian).

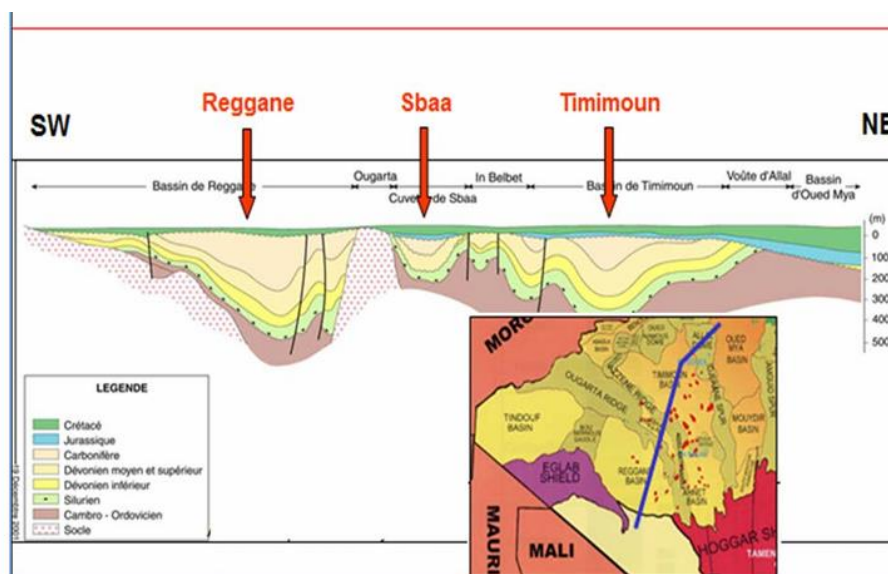


Figure I.2.: Regional Geological Cross-Section of the Timimoun, Sbaa and Reggane Basins. ^[5]

CHAPTER I: Geographic & Geological Overview of the Timimoun Field

The present stratigraphy (see Figure 1.2) results from a relatively complex geological history that led to the preservation of Paleozoic deposits (Cambrian to Carboniferous) and Mesozoic deposits (Cretaceous), marked by significant regional unconformities. These unconformities highlight plate reorganization processes (strike-slip movement and collision between “Africa” and “Eurasia”).

The Timimoun Basin experienced these global tectonic events with increased intensity due to the periodic reactivation of the Pan-African Cambrian structural lineament, which separates the Algerian craton from the West African craton. ^[6]

6. Stratigraphy of Timimoun Field

The stratigraphic succession encountered in Timimoun Basin wells belongs mainly to the Paleozoic sedimentary series of the Western Saharan Platform. These deposits overlie a Precambrian crystalline basement and include thick sequences of sandstones, shales, and siltstones deposited in marine to continental environments. The most productive gas reservoirs occur within Lower Devonian sandstones, which were deposited above Silurian shale units acting as source rocks and seals.[6]

6.1.Precambrian Basement

The base of the stratigraphic column is formed by the Precambrian crystalline basement, which represents the stable cratonic foundation of the Saharan Platform. This basement controls the overall structural architecture of the basin and the distribution of sedimentary deposits.

- **Age:** Precambrian
- **Lithology:** Crystalline basement (granite and metamorphic rocks)
- **Role:** Structural foundation of the basin
- **Significance:** Controls basin architecture and sediment thickness

6.2.Paleozoic Sequence

The Paleozoic succession is the most important stratigraphic interval for hydrocarbon exploration in the Timimoun Field.

- a. **Cambrian–Ordovician:** These formations are mainly composed of sandstones deposited in shallow marine to nearshore environments. They form potential reservoir units due to their relatively good porosity and permeability.[7]
 - **Lithology:** Quartzites, sandstones, and shales
 - **Depositional Environment:** Fluvial to shallow marine
 - **Reservoir Role:** Some sandstone intervals act as potential reservoirs.
 - **Key Reservoir Units:**
 - Hamra quartzites

CHAPTER I: Geographic & Geological Overview of the Timimoun Field

- El Goléa fluvio-glacial sandstones (important reservoir units in the Ahnet–Timimoun basin)
- b. Silurian:** The Silurian interval is dominated by organic-rich shales, particularly the Tannezuft Formation, which acts as the principal source rock for hydrocarbons in the basin and also serves as a regional seal.
 - Lithology: Organic-rich black shale
 - Environment: Deep marine
 - Petroleum System Role:
 - Main source rock in the basin
 - Also acts as a regional seal above Ordovician reservoirs.
- c. Devonian:** Devonian deposits consist of alternating sandstones, siltstones, and shales. Some sandstone intervals may act as secondary reservoirs, while shale layers provide additional sealing capacity.

Lower Devonian Reservoir Interval

The main productive reservoirs in Timimoun wells belong to Lower Devonian sandstone units.

- **Lochkovian (Gedinnian)**
 - Multilayer sandstone reservoirs
 - Good porosity values (sometimes >20%).
- **Pragian (Siegenian)**
 - Sandstone and shale alternations
 - Porosity highly variable depending on fracturing.
- **Emsian**
 - Sandstone reservoirs with porosity up to ~15% in some wells
 - Thickness of reservoir layers typically 3–6 m in certain structures.
 - These sandstones represent the main gas-producing formations in the Timimoun area.

Upper Devonian

- Lithology: Shales, siltstones, and sandstones
- Role: Secondary reservoir intervals and seals.
- d. Carboniferous:** Carboniferous sediments are less extensive but include clastic deposits that locally contribute to the stratigraphic succession.
- Lithology: Siltstones, sandstones, and shales

CHAPTER I: Geographic & Geological Overview of the Timimoun Field

- Example: Sbaa Formation, containing sandstone reservoirs with an average thickness of about 75 m in some parts of the basin.

e. Mesozoic Cover

Above the Paleozoic formations, the basin contains Mesozoic sediments, mainly Cretaceous deposits, which were preserved after significant erosional phases. These layers are separated from the underlying Paleozoic formations by major regional unconformities, reflecting tectonic uplift and erosion associated with large-scale plate movements between the African and Eurasian plates.[8]

6.3.Stratigraphic Significance

The stratigraphic framework of the Timimoun Field is characterized by:

- Thick Paleozoic sedimentary sequences hosting the main reservoirs
- Organic-rich Silurian source rocks
- Regional unconformities marking major tectonic phases
- Structural and stratigraphic traps controlling gas accumulation

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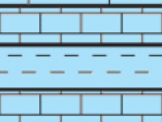
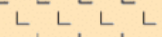
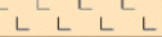
Stratigraphy			Thickness (meters)	Lithology	Description	Total petroleum system	
Cenozoic	Tertiary	Miocene	300		Limestone -claystone-sandstone	Cretaceous-Tertiary Composite	
		Oliogocene	150		Limestone-marls, shales*		
		Eocene	300		Limestone-marls, shales*		
		Paleocene	200		Limestone-marls, shales*		
Mesozoic	Cretaceous	Upper	Maastrichtian	600			Sandstone
			Senonian	900			Shale/sandstone
			Turonian	150			Bituminous shales*
			Cenomanian	600			Shales/sandy shales*
		Lower	Albian	650			Shales/siltstone/sandstone
			Aptian	1,100			Limestone/shales/sandstone
			Neocomian	500			Limestone/siltstone/sandstone
		Jurassic		2,000		Limestone/shales/evaporites	Sub-salt (hypothetical)
		Triassic		2,000		Anhydrite Massive salt	
						Clastics and lacustrine shales?*	
Paleozoic		Devonian	300		Bafata Shale	Lower Paleozoic (hypothetical)	
			150		Cusselinta Sandstone		
		Silurian	400		Buba Shale*		
		Ordovician	1,400		Gabu Sandstone		
			Cambrian	400			Caium Sandstone
		500			Cantari Shale		
350		Pirada Shale					
Precambrian undifferentiated					Metamorphic rocks		

Figure I.3: Lithological Column and Wellbore Architecture. ^[5]

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7. Reservoir Characteristics of the Timimoun Field

The main productive reservoirs of the Timimoun Basin are the Lower Devonian sandstones, which mainly contain dry gas. These reservoirs belong to the Emsian, Pragian, and Lochkovian formations, which are very thick sequences characterized predominantly by clay–sandstone facies.

These series were deposited above the Silurian shale layers within a prograding depositional system toward the north–northwest (N–NW), with a transition from fluvio-deltaic facies to shallow marine facies.

The Pragian and Lochkovian reservoirs generally have low porosity (often < 5%) and very low permeability (< 0.1 mD). However, they contain several “sweet spot” intervals with improved petrophysical properties, where porosity exceeds 7% and permeability exceeds 10 mD.

The Emsian reservoirs exhibit porosity values reaching up to 15%, with an average around 10%, while permeability values are generally greater than 0.1 mD, sometimes reaching 100 mD. The best reservoir properties are found in the Emsian formations within the eastern structures of the field area.

These characteristics may locally be improved by the presence of open or semi-open natural fractures, which enhance reservoir permeability and fluid flow.^[8]

7.1.Seal (Cap Rock)

The seal is formed by clay-rich series ranging from the Middle Devonian to the Upper Devonian, which have demonstrated their effectiveness across all hydrocarbon accumulations in the area. The ultimate regional seal is of Eifelian age, although an intermediate seal between the Emsian and the Pragian has also been identified, as indicated by different fluid contacts.

The effectiveness of seals between the Pragian and Lochkovian formations, as well as within the Lochkovian interval, although proven locally, still needs to be demonstrated at a regional scale. In addition, the role of faults as possible lateral sealing barriers remains an uncertainty that needs further evaluation.

7.2.Source Rock

The main source rocks consist of organic-rich shales of Frasnian age and those of the basal Silurian. The presence of numerous gas accumulations and fields clearly demonstrates the existence of an effective petroleum system in the region.

7.3.Migration

There is no significant risk related to migration or timing issues, based on petroleum results across the entire area. However, some uncertainty remains regarding the relative chronology

CHAPTER I: Geographic & Geological Overview of the Timimoun Field

between gas migration or remigration and trap structuring, which may influence the degree of filling of the structures. ^[7]

8. Fluid Data

The gas from the Hassi Yakour reservoir, as encountered and sampled during the Emsian DST test in well HYR-3.L1, is composed mainly of methane. The hydrocarbon composition consists of 99.2% methane (C1), 0.77% ethane (C2), and 0.04% propane (C3).

The gas has a relative density of 0.650 (air = 1). Gas analyses indicate a higher content of acid gases compared to other structures in the field, with approximately 9.2% CO₂ and trace amounts of H₂S (about 14 ppm). ^[5]

CHAPTER II:
Well Intervention Technologies:
Advanced Pipe Cutting and Tubing
Punch Operations

1. Introduction

Well intervention operations are essential in the oil and gas industry for maintaining well integrity, restoring production, and solving downhole operational problems. Among the modern intervention techniques, tubing punch technology and radial cutting systems have become effective solutions for creating communication through tubing and severing pipes without requiring costly tubing retrieval or major workover operations.

This chapter presents an overview of pipe cutting technologies, including explosive, mechanical, and chemical cutters, followed by a detailed discussion of the Radial Cutting Torch (RCT). The chapter explains the RCT components, operating principles, mechanism, advantages, and operational precautions. In addition, the principles and classifications of tubing punch technology are presented, including mechanical, hydraulic, explosive, and multi-shot tubing punch systems. Their applications, operational procedures, advantages, and limitations are also discussed to provide a clear understanding of their role in modern well intervention operations.

2. Pipe Cutters

Cutters are primarily used to cut or sever tubulars for retrieving out of hole.

Common uses include cutting tubing or drill pipe after becoming stuck in the hole, cutting and salvaging casing when economical and feasible, etc.

Explosive, mechanical and chemical cutters are currently available in the industry.

3. Types of Cutters :

3.1.Explosive or Jet Type:

A cut is made by an explosive, shaped with a concave face and formed in a circle. It is run and fired on electric line.

When the cut is made the end of the pipe is flared and requires mill over to dress off for fishing operations. The jet cutter is often used when retrieving stuck tubing or drill pipe, abandoning a well during salvage operations or when low fluid level, heavy mud, or cost would prevent the use of the chemical cutter. There is a possibility of damage to an adjacent string or to a casing if the pipe to be cut is touching at the point where the cut is made. ^[9]

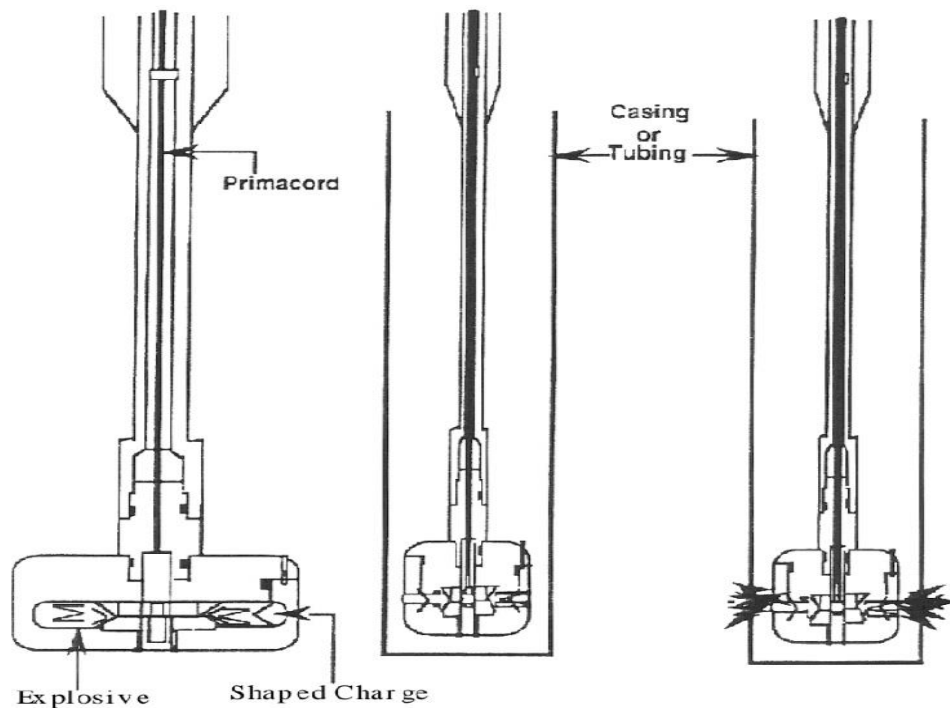


Figure II.1: Explosive Jet Cutter. ^[9]

3.2.Mechanical Type

A mechanical cutter is designed to cut pipe with a set of knives installed in a tool and run on a small diameter work string. Internal Mechanical pipe cuts are most common when removing sections of casing and wellhead equipment during final well abandonment operations.

3.3.Chemical Type

The use of a propellant and a chemical (halogen fluoride) is used to burn a series of holes in the pipe, thus weakening and making it easy to pull the pipe apart with slight pull. ^[9]

4. Definition of RCT

The Radial Cutting Torch (RCT) is used to sever tubing, casing, drill pipe, and coiled tubing without the use of explosives making it one of the safest pipe recovery tools on the market. The patented nozzle and proprietary mixture of various powdered metals produces jets of highly energized plasma to cut virtually any type of pipe in any well condition. Because RCT cutting technology does not use explosives, the tool can be shipped almost anywhere in the

world within 24 hours, saving significant time and associated costs, while remaining compliant with safety regulations.

5. Benefits & Features of RCT

5.1. Benifites

- Non-Explosive.
- Radio safe.
- Cuts are flare-free and do not produce swelling.
- Cuts in fluid or dry pipe, heavy drilling fluids.

5.2. Features

- Standard severance applications.
- Undersized for restrictions.
- HT environments.
- Cutting up to 9^{7/8}" casing.

6. Radial Cutting Torsh (RCT) Operations & Tools

6.1. RCT Assembly:

The Radial Cutting Torsh assembly includes the following equipment's:

- The cable head.
- Centrelizer sub.
- Collor locatoe assembly.
- Snicker bar.
- The isolation sub.
- The thermal generator.
- The extention adapter
- The radial cutting torsh
- The pressure balance anchor assembly
- The centrelizer sub. ^[10]

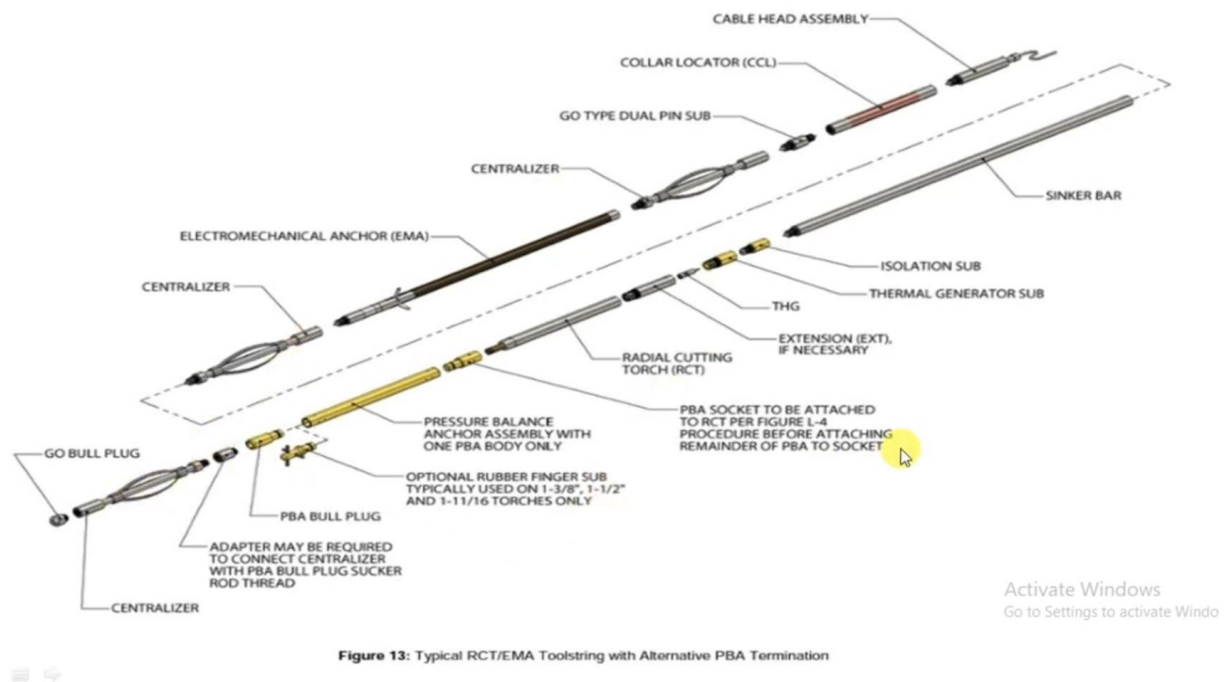


Figure II.2: Typical RCT tool string. ^[10]

6.1.1. Centrelizer sub:

A centralizer is a mechanical device used to keep a tool, torch, or drill perfectly centered within a cylindrical workpiece. In metal cutting or pipe cutting:

- It prevents the torch from deviating off-axis, which ensures uniform cuts.
- It reduces vibration and wobbling, which is critical for precise radial cutting.

Think of it as the “guide” that keeps your torch exactly in the middle of a circular or tubular object.

A centralizer in a radial cutting torch setup usually:

- Centers the torch inside the pipe or cylinder so the flame or plasma hits the metal evenly.
- Supports smooth rotation if the torch rotates around the workpiece.
- Reduces errors due to operator hand movement or uneven torch motion.
- May include rollers or bearings to allow smooth circular motion.

In short, without a centralizer, radial cutting is much less accurate and can result in irregular cuts.

6.1.2. Collor Locate

The Collar Locator Assembly is designed to position and secure a tool (like a torch or cutter) accurately on a cylindrical workpiece.

- Ensures that the cutting or machining operation starts at the exact desired axial location on the pipe or cylinder.
- Works in combination with centralizers to maintain both centering and positioning
- Especially important in radial cutting, pipe beveling, and rotational machining operations.

6.1.3. Snicker bar

In radial cutting torch operations, a Snicker Bar is typically:

- A stabilizing support bar mounted across or along the torch carriage or pipe.
- Used to prevent unwanted lateral movement of the torch during rotation.
- Ensures the cut stays precise and uniform, especially on larger diameter pipes or heavier torches.

6.1.4. The isolation sub

An Isolation Sub is a specialized component used to electrically and/or thermally isolate the torch or its carriage from the workpiece or machine body.

In radial cutting systems, its main purposes are:

a. Electrical Isolation

- Prevents unwanted electrical current from passing from the torch to the rest of the machine.
- Critical when using plasma or oxy-fuel torches, which rely on electrical arcs.

b. Thermal Isolation

Protects sensitive components of the carriage or motor from heat transfer generated by the torch.

c. Mechanical Decoupling

Sometimes, it also reduces vibration transmission, ensuring smoother radial cuts.

Without an isolation sub:

- Electrical arcs could short to the carriage, causing damage or sparks.
- Sensitive electronics in the carriage could overheat.
- Torch stability could be slightly compromised due to vibration transfer.

6.1.5. Thermal generator

In the context of an RCT tool string, the thermal generator is a subassembly that produces the heat and energy required to initiate the cutting reaction.

- The RCT uses a high-energy exothermic reaction (typically from powdered metal or chemical fuels) to produce a plasma-like jet.
- The thermal generator provides the initial thermal energy to start the reaction.
- Think of it as the “ignition system” of the downhole cutting operation.

Functionality

- Typically contains a small, controlled chemical charge or pyrotechnic initiator.
- Generates rapid heat and pressure to start the exothermic reaction in the cutting powder.
- Designed to function safely downhole and in confined tubular environments.

6.1.6. The Extension Adapter

The Extension Adapter (EXT) is a small section of machined tubing loaded with the same pellets as the main section of the RCT.

The adapter has a male thread section on the lower end and female thread section on the upper end.

The male threaded section of the extension is mated into the female thread section located at the top of the RCT.

Both ends of the Extension Adapter are sealed with an aluminum "Buffington" disc and a snap ring. O-rings are provided with the adapter.

The Extension Adapter is used to increase the load capacity of the basic RCT.

The standard RCT (without Extension Adapters) is used when the hydrostatic pressure is below 4,000 psi.

The extension adapter is added when the hydrostatic pressure is above 4,000 psi. or when a higher degree of cutting is needed such as in un-centralized cutting conditions or cutting tail pipe.

6.1.7. Pressure balance anchor (PBA)

(PBA) is a patented anchor system that uses state of the art dynamics to stabilize the RCT during the cutting operation.

Extreme forces caused by rapid pressure increases and flow velocities will cause the RCT to develop a thrust element and move up hole when fired.

The PBA harnesses these forces so that movement of the RCT during the cutting operation is prevented.

The Pressure Balance Anchor consists of a cylindrical body approximately the same diameter as the RCT.

The PBA cylinder is connected to the bottom of the RCT by means of a socket that slides over the end of the RCT cap and is held in place with setscrews. ^[11]

6.2.Theory & Operation

The Radial Cutting Torch assembly is lowered into the well on an electric wire line to the desired depth.

Current is passed through the wire line to the Thermal Generator.

The resistor in the Thermal Generator is heated to ignition temperature.

The generator creates heat to ignite the main load.

Ignition of the main load is fueled by the release of oxygen in the mixture.

The by-product of this process is heat in the form of highly energized molten plasma. This heat generated in the torch that also causes an increase in internal pressure.

Once the pressure in the torch exceeds that of the well bore, the sleeve covering the nozzle slides down exposing the nozzle to the well bore.

The molten, highly energized plasma escapes the torch body through the nozzles and is diverted 90 degrees toward the inside diameter of the tubing.

At this point, the molten plasma has the consistency and cutting action of a 6,000 degree sand blaster. ^[12]

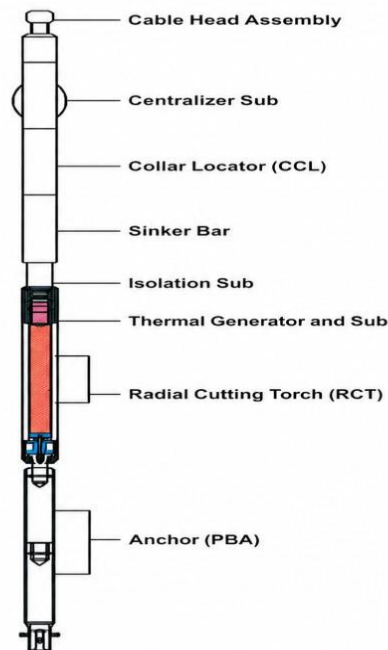


Figure II.3: Operational Assembly of the CT with Anchor and Centralizer. ^[12]

6.3.Mechanism

The powdered metal mix is pressed into solid donut -shaped pellets that are then stacked into the elongated part of the torch body.

The pellets are held in place in the body of the torch with an aluminum "Buffington" disc and a snap ring.

The new "Buffington " disc is an aluminum disc that allows the Thermal Generator to effectively penetrate the disc during initiation.

The "Buffington" disc does not need to be removed prior to assembly.

A new Isolation Sub to protect the tools located above the RCT system from being damaged by the molten plasma generated during the cutting process.

In practice certain well conditions can cause the molten plasma in the torch to move upward into the tool string and cause a great deal of damage to subs, sinker bars, collar locators and other tools attached to the RCT.

The Isolation Sub acts as a check valve to prevent this plasma from entering into the tool string above the RCT.

6.4. Precautions

NO SPUDDING: The practice of spudding (lowering the wireline at ever increasing free fall speeds in an attempt to pass through or move an obstruction or restriction in the well) should "never" be attempted.

Spudding can cause damage to the torch and a sudden ingress of well bore fluid and pressure to the main load that can result in premature ignition.

PLUGGED TUBING: Tubing that is plugged or that is collapsed or restricted in any way.

When fired in these cutting situations the RCT will become unbalanced and will be lifted upward by the escaping plasma. Not only will the RCT not cut the tubing, but severe damage will occur to the tool string and the tools above the RCT will be thermally gutted (the isolation sub may prevent most of this).

The RCT will also sustain damage and can weld itself to the tubing

NO PUMPING WHILE RUNNING: The RCT should not be run when pumping into a well that is taking fluid.

Fluid moving past the RCT may destabilize the RCT and cause it to move during the cutting operation., Thus 2000 ft of water must be above RCT or ass anchor.

RUN GAGES PRIOR TO RUNNING RCT: A drift gauge must always be run prior to running the RCT to insure that there are no obstructions or restrictions in the wellbore that would prevent the tool string from getting to depth.

A dummy run without the live RCT must be run whenever a no-go gauge is used.

This will insure that the RCT will pass through any restriction or obstruction in the well.

NEVER REMOVE SLIDING SLEEVE: Do not remove the sliding sleeve from the torch, as damage may occur to the o'rings when repositioning the sleeve onto the RCT. This will cause the damage to the RCT and will cause the RCT to malfunction.

MAXIMUM RUNNING SPEED: The maximum running speed for the RCT system in clean unrestricted and unobstructed tubing, casing or drill pipe is three hundred feet per minute provided a dummy gauge run has been made prior to running the live RCT. ^[13]

7. Tubing Punch Technology

7.1.Principle of Tubing Punch Technology

The basic principle of tubing punch technology consists of creating one or more small-diameter holes through the wall of the production tubing using a specialized downhole tool. These holes allow fluid or gas communication between the tubing and the annulus.

The punching operation is performed without pulling the tubing, using conveyance systems such as slickline, wireline, or coiled tubing. Once activated at the target depth, the tool generates sufficient mechanical, hydraulic, or explosive energy to penetrate the tubing wall while maintaining well control.

The operation is designed to be localized, controlled, and irreversible, ensuring minimal impact on overall well integrity while achieving the required hydraulic communication.

7.2. Components and Design of Tubing Punch Tools

A typical tubing punch tool consists of the following main components:

7.2.1. Tool Body

The tool body is a high-strength steel housing designed to withstand downhole pressure, temperature, and mechanical loads. It contains the internal activation system and punching mechanism.

7.2.2. Punching Mechanism

Depending on the tool type, this may include:

- Hardened steel punch pins
- Pistons
- Shaped explosive charges

These elements are responsible for penetrating the tubing wall and creating the required openings.

7.2.3. Activation System

The activation system initiates the punching action and may be:

- Mechanical (weight or impact activated).
- Hydraulic (pressure-driven).
- Electrical (E-line signal).
- Explosive (controlled detonation).^[9]

7.2.4. Safety and Control Features

Modern tubing punch tools include safety mechanisms to prevent premature activation and ensure controlled operation, particularly in high-pressure gas wells.

7.3. Types of Tubing Punch Technology

Tubing punch tools can be classified into several categories based on their activation method:

7.3.1. Mechanical Tubing Punch

The Mechanical Tubing Punch is designed to be able to punch holes in downhole tubing. Once the hole has been made in the tubing the punch will retract into the tool allowing the tool to be pulled from the bore. It is used to aid in the draining of fluid from the tubing when the tubing needs to be removed from the well. It can also be used as a method to allow communication between the tubing and casing for injection of chemicals or to circulate kill fluid. Another use is to allow additional productive zones to be introduced to the production string when required.

Applications

- Draining fluid from the tubing when it needs to be removed from the well.
- Communicating between the tubing and casing.
- Selectively perforating the inner pipe without damaging the outer casing or annular string.
- Key Features & Benefits
- Operates without explosives, enhancing safety during handling and logistics.
- Multiple tool sizes for a variety of tubing diameters.
- Utilizes upward jarring to punch holes.
- Standard tools utilize a jar up to punch design which relies the tool serrations gripping the tubing.
- A down to punch variation is available upon request, which can be activated on top of a set anchor.^[14]

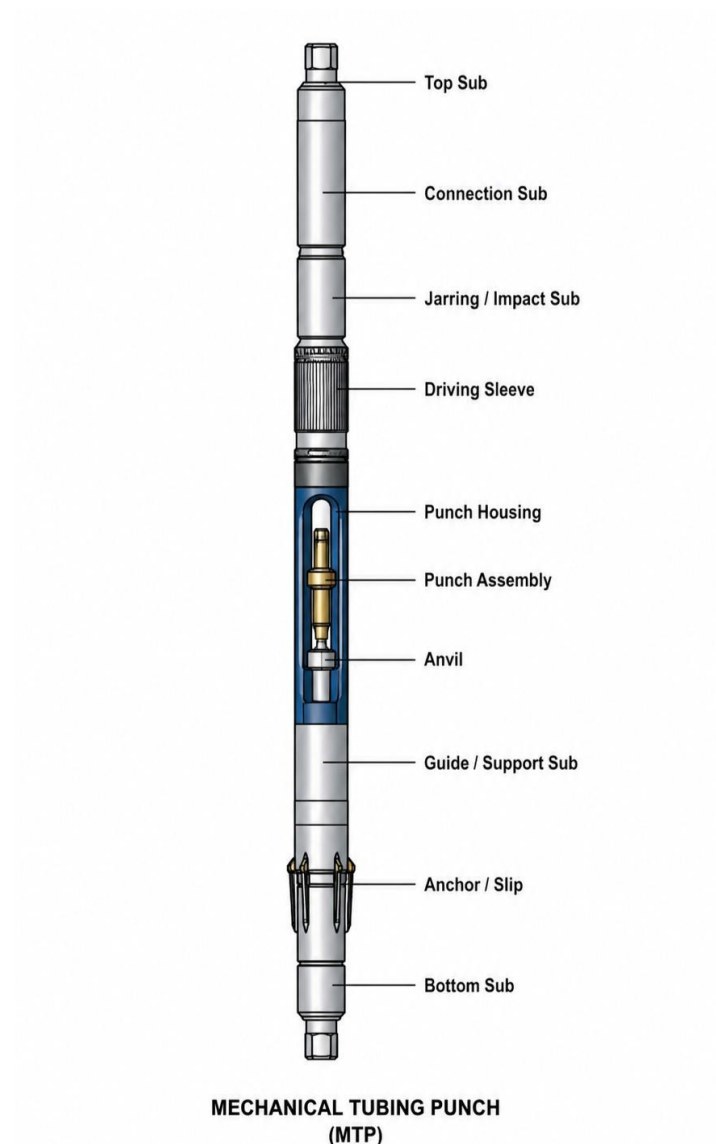


Figure II.4: Mechanical Tubing Punch. ^[14]

7.3.2. Hydraulic Tubing Punch

Hydraulic punch tools utilize applied pressure to actuate pistons that force the punch pins outward. These tools provide better control and are suitable for deeper wells and higher pressures.

Operation

Assemble the components of the Hydraulic Tubing Punch and attach to the tool string.

Once attached to the tool string release the safety sleeve, and lower into the wellbore to the desired depth, setting down on a pre run collar stop or other firm base. Jar down to shear the shear pin and detonate the charge. The punch is forced through the tubing wall when the firing shell is detonated. Gas pressure build up above the piston forces the piston down which displaces the oil in the oil chamber to the punch housing. The oil pressure transmitted to the punch housing shears the punch piston pin forcing the punch piston from the punch housing and through the tubing wall.

The outside end of tapered punch being larger in diameter than the inside end allows the punch to fall outside tubing and be clear of the perforator.

The hydraulic perforator is designed for three common tubing sizes; 2.375, 2.875 and 3.50 inch tubing. With the use of larger OD sleeves and longer punch piston the 2.375 perforator is converted to 2.875 and 3.50 inch.

Two styles of firing pins and shell caps are available which are rim fire or center fire. The style of firing pin must be matched with the charge.^[14]

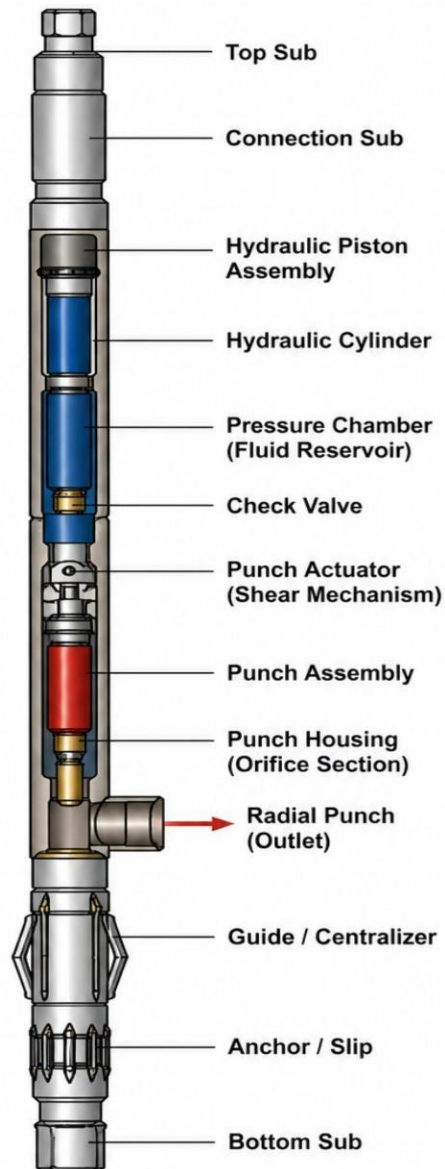


Figure II.5: Hydraulic Tubing Punch. ^[14]

7.3.3. Explosive Tubing Punch

Explosive punch tools employ small, precisely engineered shaped charges to penetrate the tubing wall. They are effective in thick or high-strength tubing and are commonly used in high-pressure gas wells.

Characteristics

- High penetration capability
- Controlled hole diameter
- Suitable for thick-wall tubing
- Can be conveyed using slickline or coiled tubing

Operational Conditions

- Rated for high-pressure environments
- Suitable for high-temperature wells
- Requires proper decentralization to avoid casing damage

7.3.4. Multi-Shot Tubing Punch

Multi-shot tools can create several holes in a single run, increasing flow capacity and improving pressure equalization between tubing and annulus.

7.4.Operational Procedure

The tubing punch operation follows a structured and carefully planned procedure:

7.4.1. Pre-Job Engineering Evaluation

- Review of well data (pressure, temperature, tubing size, material)
- Risk assessment and well control planning
- Selection of appropriate tubing punch tool

7.4.2. Tool Deployment

The tool is run into the well using slickline, wireline, or coiled tubing. Depth correlation is performed using well reference data to ensure accurate positioning.

7.4.3. Activation and Punching

Once at the target depth, the tool is activated according to its design. The punch pins or charges penetrate the tubing wall, creating controlled openings.

7.4.4. Post-Punch Verification

Pressure monitoring and flow tests are conducted to confirm successful communication between the tubing and annulus.

7.5.Applications of Tubing Punch Technology

Tubing punch technology is applied in various well intervention scenarios, including:

- Pressure equalization between tubing and annulus
- Annulus fluid circulation and bleeding operations
- Well killing and abandonment preparation
- Gas venting to prevent tubing collapse
- Production restoration in wells with stuck plugs
- Intervention in highly deviated or horizontal wells

In gas wells, tubing punch operations are particularly effective for restoring production when mechanical obstructions prevent access to the lower completion

7.6. Advantages of Tubing Punch Technology

The main advantages of tubing punch technology include:

- Elimination of tubing retrieval, reducing cost and rig time
- Applicability in live wells with proper well control
- Suitability for highly deviated wells
- Rapid execution and operational simplicity
- Minimal surface footprint compared to major workovers

7.7. Limitations and Risks

Despite its advantages, tubing punch technology has certain limitations:

- Permanent damage to the tubing string
- Limited hole diameter compared to perforating operations
- Risk of tool sticking or misfire
- Potential for uncontrolled flow if not properly managed

These risks necessitate thorough engineering evaluation, strict safety procedures, and experienced operational personnel.

7.8. Role of Tubing Punch Technology in Production Restoration

In production restoration operations, especially in gas wells with stuck plugs, tubing punch technology provides a practical alternative to more invasive interventions. By re-establishing pressure communication and enabling controlled gas flow, production can be restored without major mechanical intervention.

In highly deviated wells, where conventional fishing or milling operations may be technically challenging or economically unjustifiable, tubing punch operations often represent the most efficient solution. ^[15]

8. Conclusion

Tubing punch technology and Radial Cutting Torch (RCT) systems are important tools used in modern well intervention operations for pipe cutting, pressure equalization, and production restoration. These technologies offer practical and cost-effective alternatives to conventional workover methods by reducing rig time and eliminating the need for tubing retrieval in many cases.

This chapter demonstrated that different cutting and punching systems can be selected according to well conditions, operational objectives, and safety requirements. The RCT provides efficient non-explosive cutting performance, while tubing punch technologies enable controlled communication between the tubing and annulus in challenging well conditions. Despite certain operational limitations and risks, proper engineering design, tool selection, and adherence to safety procedures ensure successful and reliable intervention operations, particularly in highly deviated and gas wells.

CHAPTER III: Production Restoration in HYR-03 Well Using Tubing Punch Technology

1. Introduction:

The objective of this chapter is to define and implement the optimal restart strategy for well HRY-03 to restore production, maximize deliverability, and ensure the integrity of the downhole equipment and reservoir, while minimizing operational costs.

2. HYR-03 Well:

2.1.Situation:

The Hassi Yakour-3.L2 well (HYR-3.L2) is a sidetrack of the HYR-3.L1 well. It is located on the southeastern flank of the Hassi Yakour structure, within the Timimoun Central exploitation area. The area lies on the Tademaït Plateau, at the southern margin of the Grand Erg Occidental (Sahara Desert), approximately 600 km southwest of Hassi Messaoud. ^[5]

2.2.Surface Location

Seismic Location: XL 9839 / Random Lines W–E

Geodetic System: Datum: North Sahara 1959 – Timimoun / In Salah

Ellipsoid: Clarke 1880 RGS

Projection: UTM Zone 31 North

Central Meridian: 3° East

Surface Coordinates :

- Longitude: 01°32'58.845'' E
- Latitude: 28°25'55.401'' N
- UTM X: 357,961 m
- UTM Y: 3,145,671 m
- Ground Elevation (Zsol): +427 m
- Rotary Table Elevation (Z RT): +436 m

Top Emsian Reservoir Coordinates:

- UTM X: 357,784 m
- UTM Y: 3,145,701 m
- Depth: 2250 m TVD/RT (–1814 m MSL)

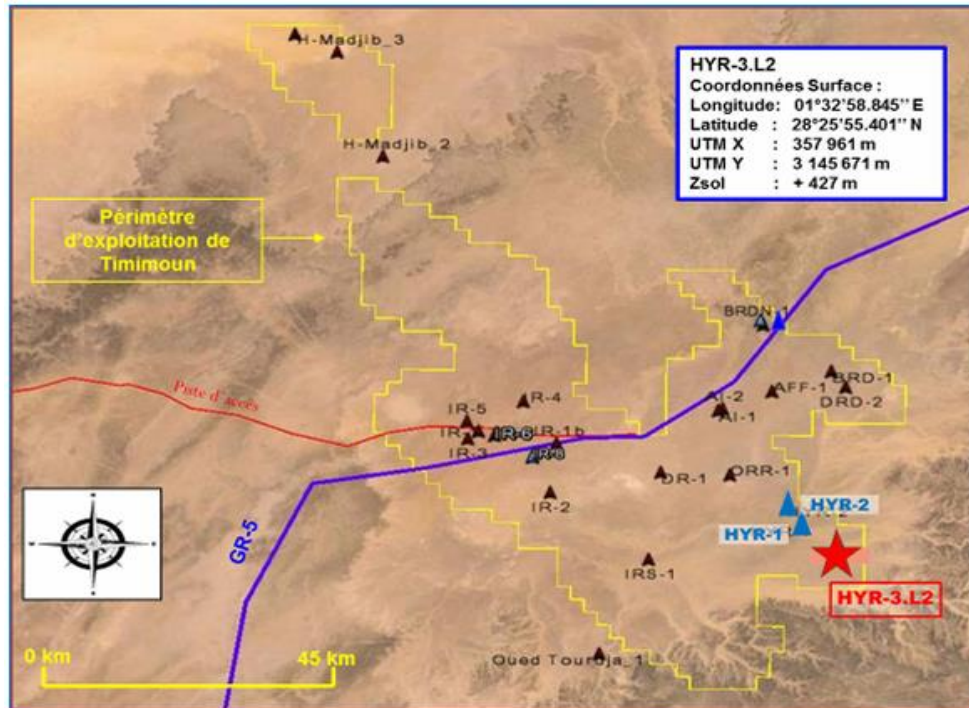


Figure III.1: Location of Hassi Yakour 3. ^[5]

3. Drilling Well History

The Hassi Yakour structure, discovered by Sonatrach in the Lower Devonian reservoirs, was initially drilled by two wells: HYR-1, drilled in 1981 at the crest of the structure, and HYR-2, drilled in 1985 on its northern flank.

The wells HYR-3 and HYR-3.L1 were drilled by the Timimoun Association (TEPA–Sonatrach–CEPSA) during the second exploration phase within the Timimoun permit, with the objective of evaluating the Lower Devonian reservoirs (Emsian, Pragian, and Lochkovian).

The HYR-3.L2 well is located approximately 5 km southeast of HYR-1 and 8 km southeast of HYR-2. This sidetrack is planned to be drilled after the development well HYR-5, using the same drilling rig (ST14).

The deviated well HYR-3 drilled the entire overburden section down to a depth of 2419 m (2290 m TVD/GL; -1863 m MSL) in preparation for initiating a 65° drain section. A 9 5/8" casing was run to cover the shale formations and the Emsian reservoir at 2408.4 m.

The pilot well HYR-3.L1 was drilled after milling a window in the casing at the Eifelian level, with a trajectory decreasing from 24° to 11.5° at the top of the Lochkovian. Drilling was stopped at the top of the Silurian formation at 2782.4 m (2734 m TVD/GL; −2307 m MSL) following a drill string failure (fish top at 2662 m).

After disassembly of the Adaptor, degradation of the TH neck was observed due to corrosion.

Attempts to remedy this by cleaning and replacing THA and SRL seal were unsuccessful. It was decided to plan for a workover for a complete check/remedy of the issue.

On 28/02/2023, following instruction, BPV has been retrieved and pressure gauge installed on TH cavity test port. Well production started on 4th of april 2023, once production surface equipment were re-installed.

Well was shut in on the 4th of july 2023, and production equipment were dismantled in order to allow work-over rig to be installed.

Well intervention operations started on 12/10/2026 with running an EZ Drill packer to isolate the well from the formation and set it below the existing packer depth at 1983 m RT, with the EZ plug landed around 2005 m inside the 4.5” tubing. Tubing was punched at 1954 m to equalize pressure between tubing and annulus, and the well was displaced with 1.2 sg NaCl brine. ^[16]

5. During the workover operations:

Multiple attempts were performed to cut the tubing using Radial Cutting Torch (RCT), with two unsuccessful cuts at 1975 m and 1976 m, before successfully cutting the tubing at 1956 m on 16/10/2023.

During retrieval, when going through the TR-SCSSV, tool stuck, tension increased suddenly, prior dropping as cable got cut at the TR-SCSSV level.

Completion was subsequently retrieved and the and hole cleanout operations after that a new completion run in the hole.

TR-SCSSV was checked, tubing hanger installed, tubing pressure tested, and several slickline runs with 3.5” gauge cutter confirmed partial access toward bottom.

The final well status indicates the well is isolated from bottom with an EZ plug set at 2002 m below the original packer inside the 4.5” tubing, while a remaining 1.88 m long, 2.5” OD fish is still left above the plug and requires retrieval. Permanent completion has been installed and packer set successfully, although approximately 26 m of tubing above the original packer remains damaged.

well was kept close a communication with reservoir has been established and well head pressure started showing pressure build up. ^[16]

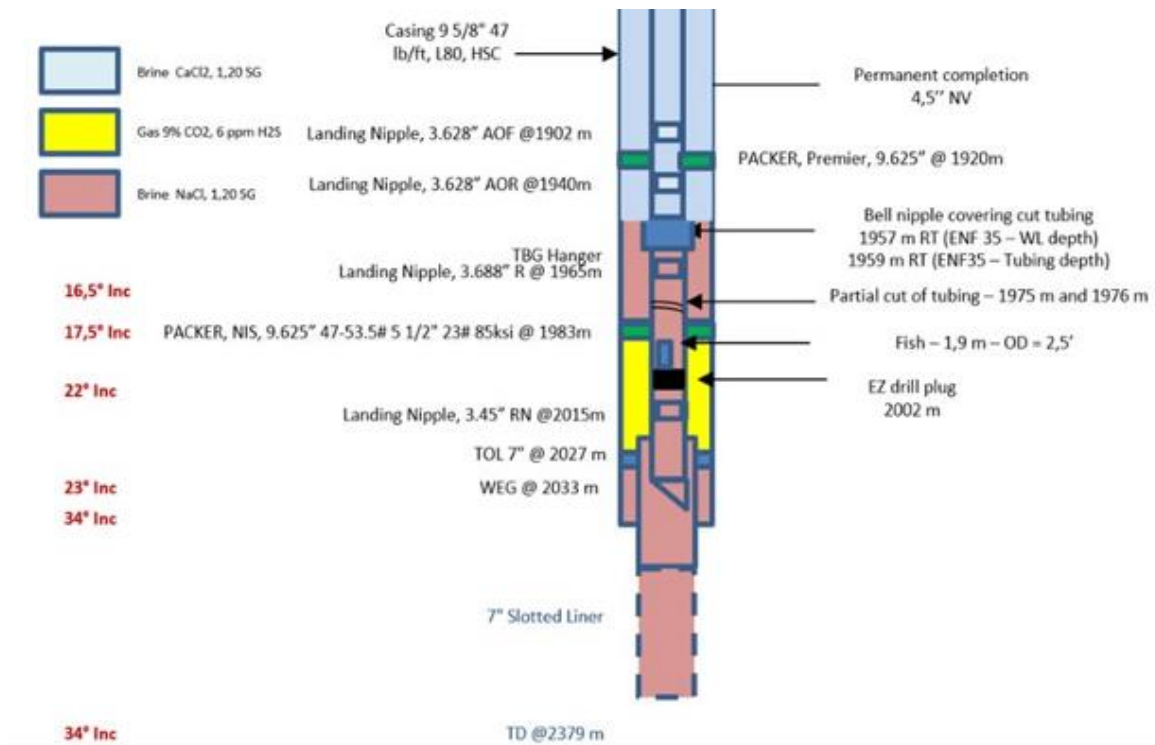


Figure III.3: The Final Well Status. ^[16]

6. Tubing Punch Preparation

6.1.Evaluating Well Productivity Enhancement Through Tubing Punching:

Following the failure to retrieve the stuck plug from HYR-03, it was recommended to punch the tubing below the NIS packer (1984 m). A high-level review was carried out to evaluate the well performance considering multiple tubing punches.

Based on 6 punches of 2" each. Annular flow below the restriction was considered in the assessment, assuming no flow through the stuck plug.

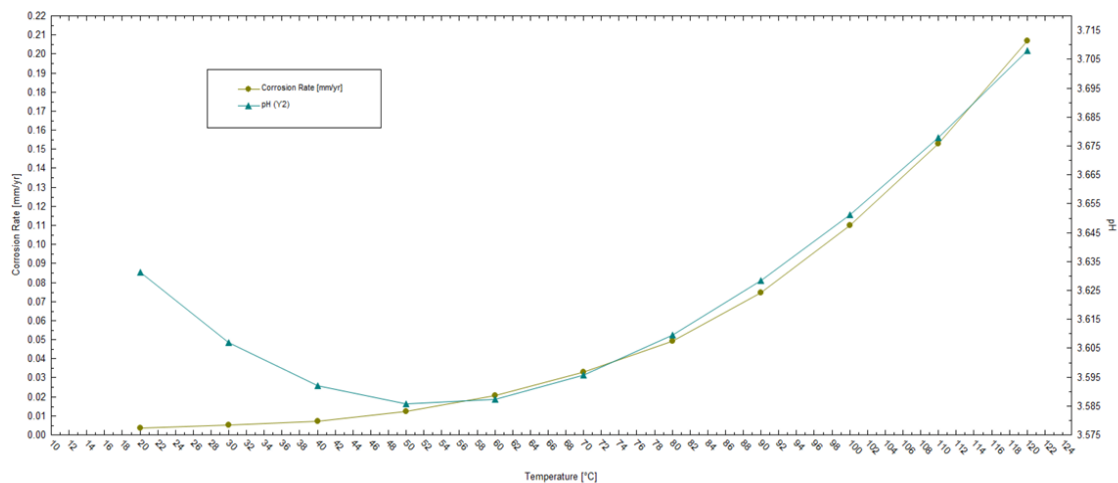
Post tubing punching, based on the assumed reservoir input data and well performance evaluation, a production rate of 300 KSm³/day is expected to be achievable with the tubing punch below the packer depth.

6.2.Impact of Punching Operation on NIS Packer Elements at 1984 m:

The Completion team was consulted regarding the potential impact of the planned punching operation on the NIS packer elements. It was confirmed that no adverse impact on the packer is expected, as the NIS is a permanent packer and the only retrieval method is through milling operations.

6.3.Casing Corrosion and Erosion Study for Well Integrity Impact Assessment:

- The 9-5/8" L80 casing inner surface, exposed to the Annulus A, between the NIS packer at 1984.75m and the 7" TOL at 2027.5m, total length +/- 40m will be susceptible to corrosion, during the static conditions.
- The indirect exposure, due to flow from the 7" TOL to the 9.625" x 4.5" Annulus A – Semi-static condition (Before Punching the tubing)
- The direct flow exposure, due to flow path of: 4.5" tubing x 7" Liner annulus → 4.5" tubing x 9.625" annulus until NIS Packer → Inside the 4.5" tubing from the punches (After tubing punching & installing bridge plug)
- Shut-in conditions with the casing exposed to condensed water tubing from the punches (After tubing punching & installing bridge plug)
- Shut-in conditions with the casing exposed to condensed water
- The worst-case wall thickness reduction is in the case of well shut-in static condition, & the corrosion due to condensed water.
- The minimum wall thickness reduction due to corrosion will be in shut-in condition, the pipe in contact with water i.e., 11.4 mm/yr. The stress analysis of the pipe, with reduced wall thickness, shows collapse failure of the pipe under production loads.
- No sand production is observed from the well. The flow velocities of gas and water are also below the erosional threshold and hence there is no potential wall thickness reduction due to erosion. [16]



Static Condensed Water Rate

Figure III.4: Corrosion Rate in Static Conditions [16]

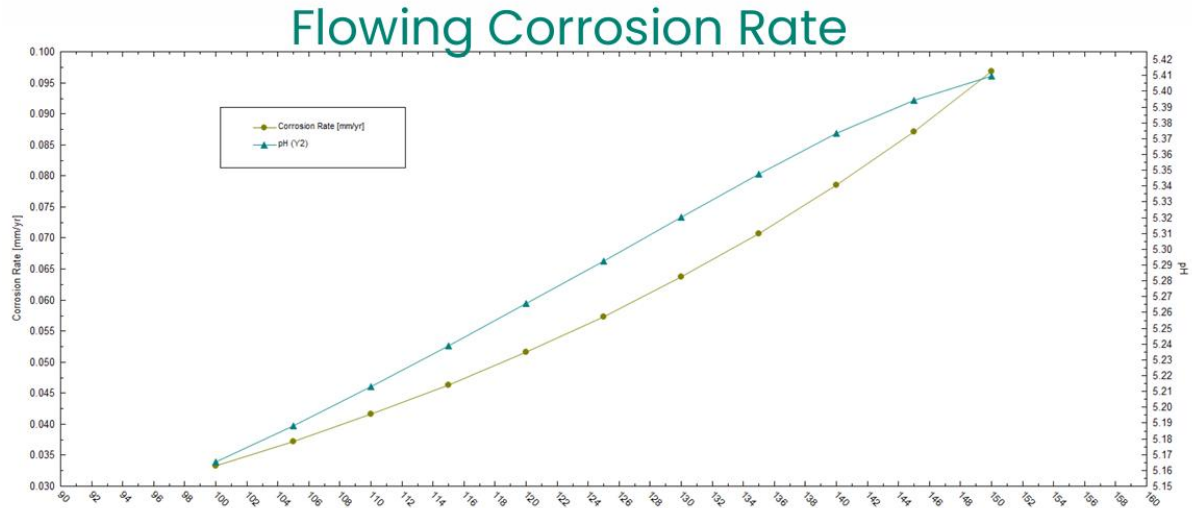


Figure III.5: Corrosion Rate in Flowing Conditions. ^[16]

7. Tubing Punch:

Tubing punch technology is mainly used to create communication between the tubing and the annulus in a well.

Electric tubing punch: This system operates similarly to a perforating gun but with limited penetration depth to avoid damaging secondary barriers such as the casing. It is faster, more efficient, and provides more accurate depth correlation through the use of Casing Collar Locator (CCL) logs. The gun assembly is typically conveyed by electric wireline. ^[17]

7.1.Tool String Used to Punch in HYR-03:

Tool String consisting of:

- **Wireline cable:** A wireline cable is the main cable used to lower and retrieve tools inside the wellbore during wireline operations. It connects the downhole tool string to the surface unit
- **Cable Head:** The cable head is the connection between the wireline cable and the downhole tool string. It is one of the most important safety components in wireline operations.
- **Weight Bar:** The weight bar (often called a sinker bar) is a heavy steel bar added to the wireline tool string. It provides weight and stability while running tools in the well.
- **CCL:** Casing Collar Locator it is a depth-correlation tool that detects the joints (collars) between sections of casing tubing or casing pipe in the well. ^[18]

The CCL helps confirm:

- correct depth inside casing/tubing
- location relative to known collars
- matching against completion diagrams or old logs

Without CCL, depth error from cable stretch or wheel slippage can cause misplacement. ^[17]

- **PTS:** In slickline or wireline operations, PTS usually means Pressure Temperature Survey or sometimes Pressure Temperature Spinner tool. It is a downhole logging tool used in oil, gas, and geothermal wells to measure conditions inside the wellbore.
- **PBA:** In wireline or slickline intervention toolstrings, PBA commonly means Perforating Bottom Assembly. It is the lower section of the toolstring that contains the actual perforating or punching equipment used to create holes in tubing or casing. In tubing punch operations, the PBA may include:

- tubing punch gun
- shaped charges
- jet perforator
- firing head
- detonator components
- pressure barriers/safety sections

A typical electric wireline tubing-punch string may look like where:

- CCL → depth correlation
- PTS → pressure/temperature survey
- PBA → punching/perforating assembly ^[19]

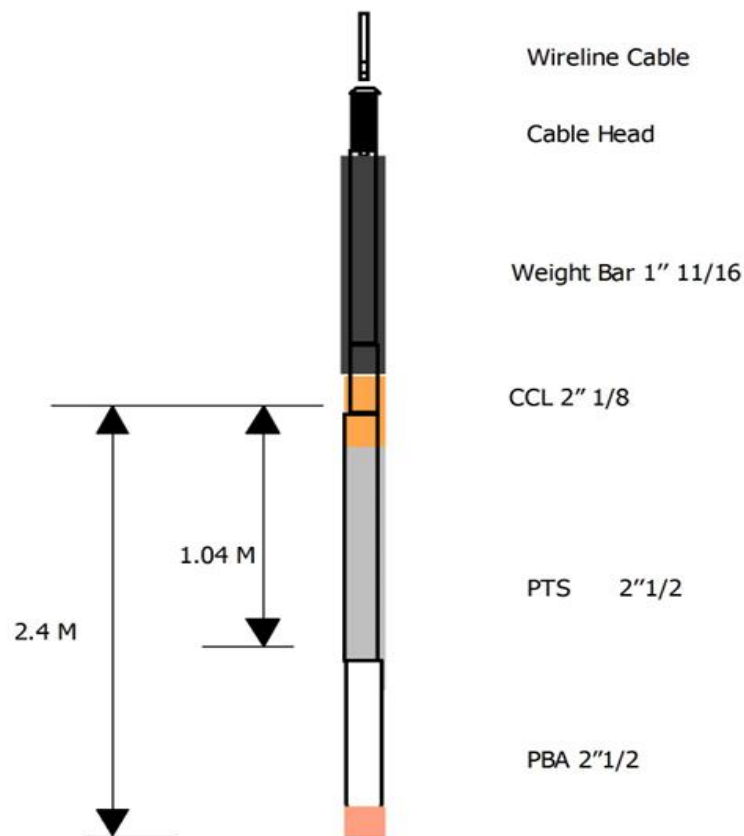


Figure III.6: Tool String Used to Punch in HYR-03. ^[18]

On 05/01/2024, the E/L tubing punch job had the previous puncher tool; the shooting interval is (1987-1989 m), duration was one day operation, good indication of firing POOH 6 holes was created with average size is 2”.

7.2.Punch Log:

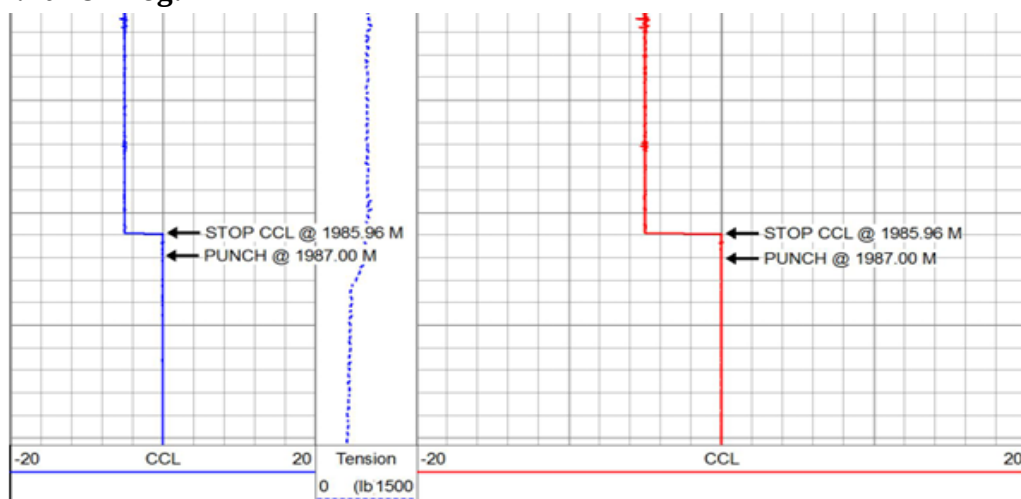


Figure III.7: Punch Pass at 1987 m. ^[18]

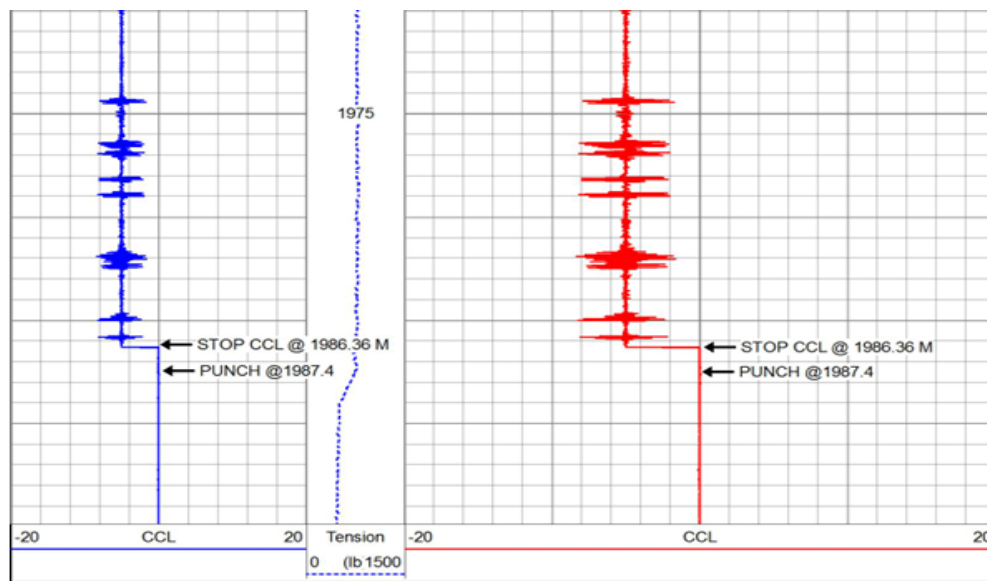


Figure III.8: Punch Pass at 1987.4 m. ^[18]

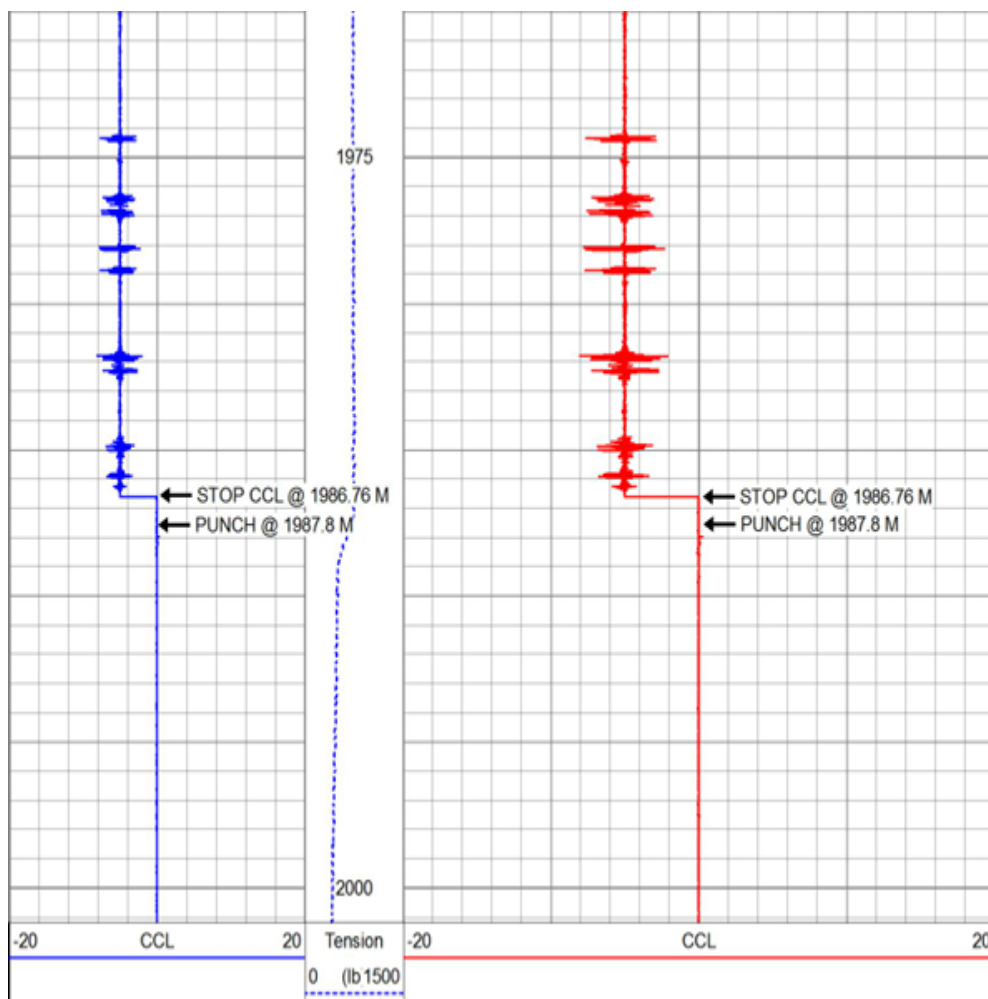


Figure III.9: Punch Pass at 1987.8 m. ^[18]

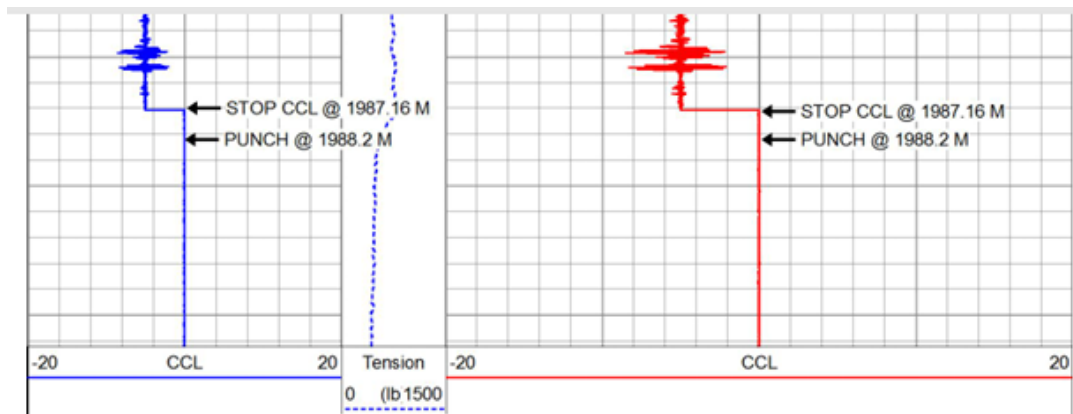


Figure III.10: Punch Pass at 1988.2 m. ^[18]

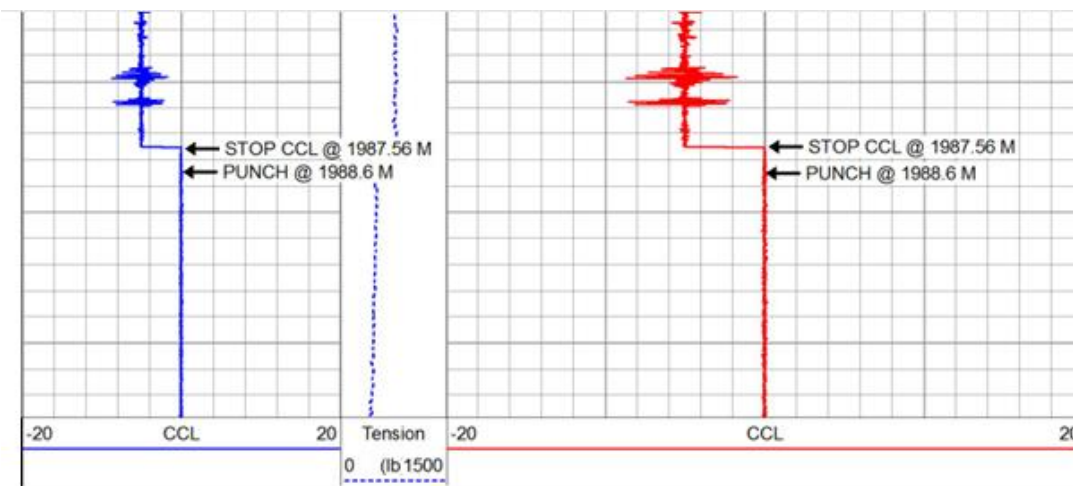


Figure III.11: Punch Pass at 1988.6 m. ^[18]

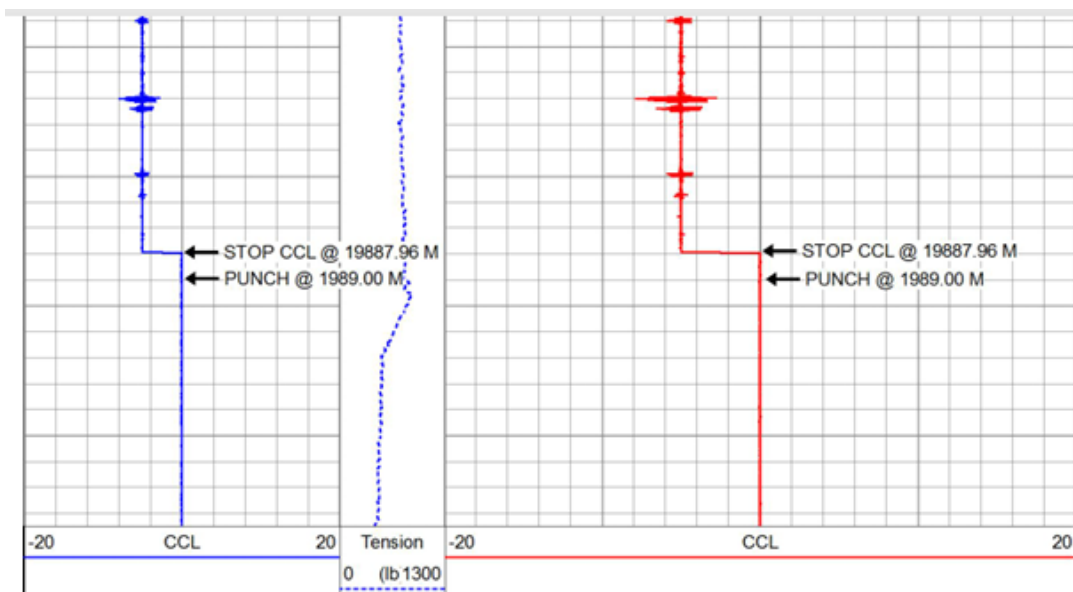


Figure III.12: Punch Pass at 1989 m. ^[18]

8. Well Schematic Design After Tubing Punch Operation:

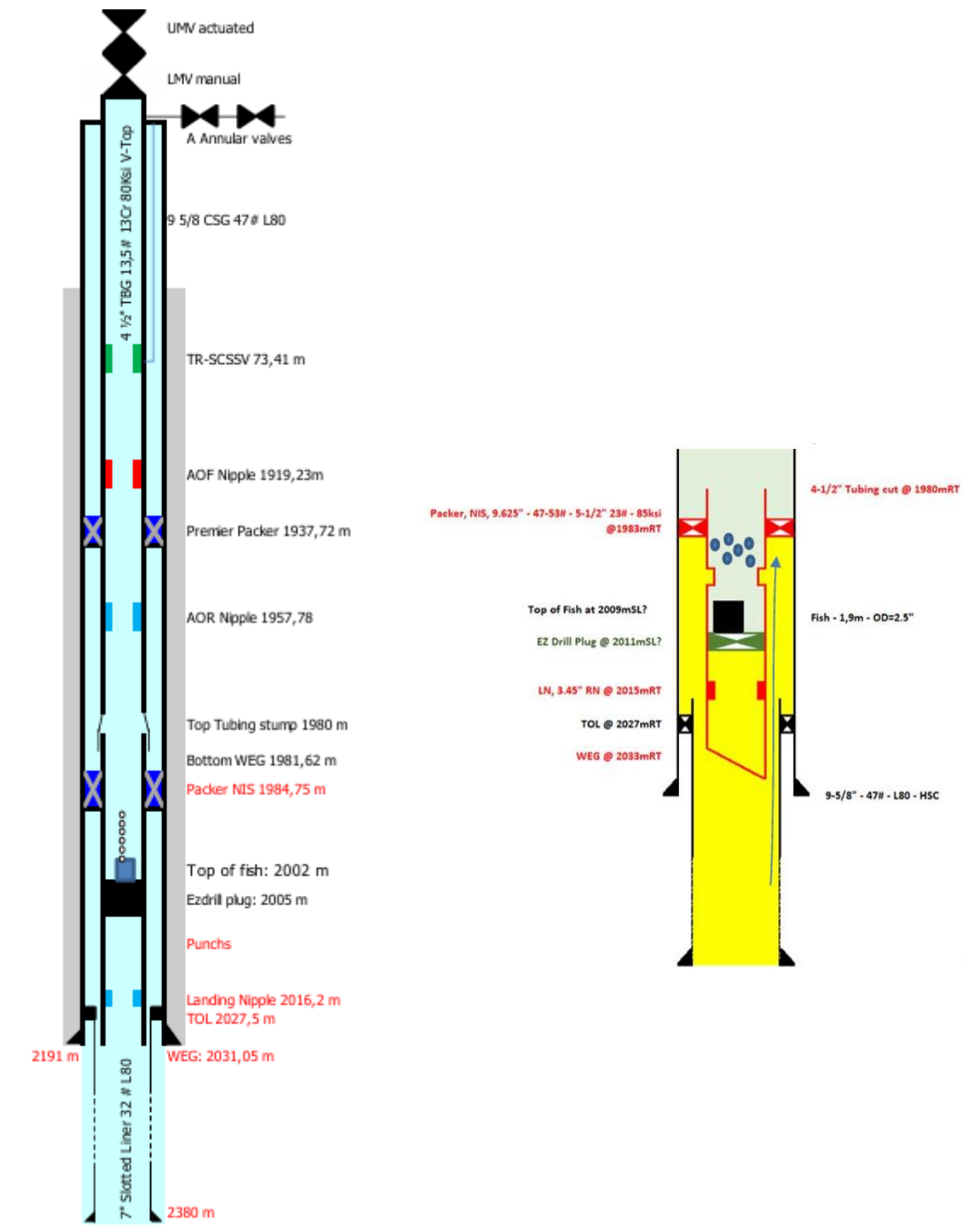


Figure III.13: Well schematic design of HYR-03. ^[16]

9. Well performance evaluation after Tubing Punch:

With current well production, with the plug body stuck in place, and with the current reservoir condition, the well is meeting the allowable production target. The job has been considered successful, and no immediate actions are required. With multiple tubing punch Approximately 250 Ksm³/ day of production was achieved, which is close to the initial production rate for this well. All remedial actions were done rigorously with the least risk and optimized cost.

10. Conclusion

The application of tubing punch technology in well HYR-03 proved to be an effective solution for restoring production in a highly deviated gas well affected by a stuck plug and completion restrictions. Following several unsuccessful conventional intervention attempts, the tubing punch operation enabled communication between the reservoir and the tubing below the permanent packer without requiring a major workover or tubing retrieval operation. The operation successfully restored gas production to a level close to the well's initial performance while reducing intervention time, operational complexity, and associated costs. These results demonstrate that tubing punch technology is a safe, efficient, and cost-effective alternative for solving complex production challenges in highly deviated gas wells and extending their productive life.

GENERAL CONCLUSION

GENERAL CONCLUSION

This dissertation highlighted the importance of advanced well intervention technologies in restoring production and maintaining well integrity in complex gas well environments. The study focused on the successful application of tubing punch technology in the HYR-03 well located in the Timimoun gas field in southwestern Algeria.

The geological and reservoir analysis demonstrated that the Timimoun Basin contains significant Lower Devonian gas reservoirs characterized by low permeability, structural complexity, and operational challenges typical of Saharan gas developments. These characteristics require reliable and efficient intervention methods capable of minimizing operational risks while maintaining production performance.

The theoretical study of well intervention technologies showed that Radial Cutting Torch (RCT) systems and tubing punch operations provide effective alternatives to conventional workover techniques. Their ability to perform cutting and communication operations without full tubing retrieval significantly reduces rig time, operational complexity, and intervention costs. In addition, the non-explosive and controlled nature of these technologies improves operational safety, especially in high-pressure gas wells and highly deviated completions.

The HYR-03 case study demonstrated that conventional intervention methods were insufficient to solve the operational problems caused by the stuck plug and completion restrictions. After several unsuccessful attempts to retrieve or cut the tubing, tubing punch technology was selected as the most appropriate solution for restoring communication between the reservoir and the production tubing.

Comprehensive engineering evaluations confirmed the technical feasibility and integrity of the operation. Productivity forecasts, packer integrity assessment, and corrosion studies ensured that the tubing punch operation could be safely executed without compromising well integrity. The successful creation of six tubing punches below the permanent packer allowed pressure communication and restored gas production with minimal operational risk.

The results obtained after the intervention confirmed the effectiveness of the selected solution. Gas production reached approximately 250–300 KSm³/day, close to the well's initial production rate. Furthermore, the operation was completed through a rigless intervention, reducing costs and avoiding a major workover operation.

In conclusion, tubing punch technology proved to be a reliable, safe, and cost-effective solution for restoring production in highly deviated gas wells affected by stuck plugs and completion restrictions. This study demonstrates the significant role of modern well intervention technologies in optimizing production, reducing operational costs, and improving field performance in challenging petroleum environments.

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