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A Summer Internship Report Entitled

Pipeline Integrity Management

Submitted by

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BACHELOR OF TECHNOLOGY
in
APPLIED PETROLEUM ENGINEERING WITH SPECIALIZATION IN GAS

Under the mentorship of

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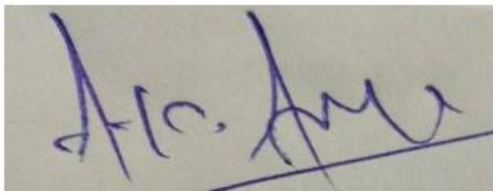
CERTIFICATE

This is to certify that the Summer Internship Report entitled, **"PIPELINE INTEGRITY MANAGEMENT"** submitted by **SAURABH MATHUR (R820218149) , ANIMESH AGARWAL (R820218021) , SRISHTI MEDHA (R820218171) , HARDIK SHARMA (R820218205) , SHAHBAZUR RAHMAN (R820218152),** to the **UNIVERSITY OF**

PETROLEUM & ENERGY STUDIES , for the award of the degree of **BACHELOR OF TECHNOLOGY** in **APPLIED PETROLEUM ENGINEERING** with specialization in **GAS STREAM** is a bonafide record of work carried out by them under my mentorship. The content of the report, in full or parts have not been submitted to any other institute or University for the award of any other degree or diploma.

Name of Mentor – DR. ADARSH ARYA ASSISTANT PROFESSOR
Department of Chemical Engineering



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DECLARATION BY THE SCHOLARS

We hereby declare that this submission is our own and that , to the best of our knowledge and belief. It contains no material previoulsy published or written by another person nor material which has been accepted for the award of any other Degree or Diploma of the University or other Institute of Higher learning , except where due acknowledgement has been made in text.

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ABSTRACT

Pipelines are the safest, most cost-efficient transportation mode for oil, gas, and petroleum products. Being a crucial component in contemporary infrastructure, loads of thousands of kilometres of transportation pipelines stretch all through the globe to supply the ever- developing energy market. Integrity Management Programs (IMPs) are chance control programs with provisions for supply activities concerned with sustainable and non-prevent self-assessment and improvement. The performance-based totally completely programs allow the operator control risk and optimize safety, reliability, and cost thru manner of way of wondering about uncertainties rather than following strict guidelines. A pipeline integrity control software is wanted for those pipeline structures to growth their reliability and availability, and to successfully control and minimize maintenance, repair, and alternative prices over the lengthy run. In this repot we've got covered many models concerning Pipeline integrity control programs (PIMS) and proposed frameworks furthermore, an in depth look at on subjects such Quality Control, Leak detection strategies and maximum vital effects found out from two decades of demanding situations to inner corrosion safety of subsea pipelines corrosion inhibitor and Ph control, corrosion inhibitors nonetheless, an in depth case look at on Dow Deutschland Anlagengesellschaft mbH (DOW) Ohrensen, Germany and Reinhart Hydrocleaning SA (RHC SA) changed into carried on and the effects had been studied and evaluated. A reliable, secure and environmentally accountable pipeline industry is crucial to the nation.

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CHAPTER ONE
INTRODUCTION

Pipelines are the safest and cost efficient transportation mode for oil, gas, and petroleum products. Being a vital factor in present day supply infrastructure, hundreds and thousands kilometers of transportation pipelines stretch throughout the globe to deliver the ever developing supply market. Integrity Management Programs (IMPs) are threat control packages with provisions for supply involved with sustainable and non-stop self-evaluation and development. The performance based packages permit the operator to control threat and optimize safety, reliability, and price via means of thinking about uncertainties as opposed to following strict guidelines. Risk based techniques offer this capability and the remaining activities in IMP are policies to make certain non-stop operation and self-development in place of handling structural integrity. Figure 1 suggests how the threat based techniques shape into an IMP structure. All threat control packages include stages, Risk Analysis and Risk Control. Pipeline integrity control emerges from combining the structural fitness of the asset with threat control. Over time, and because of the legislative development toward imposing threat- primarily based totally techniques in pipeline control, studies on this Pipeline integrity management emerges from combining the structural health of the asset with risk management. Over time, and due to the legislative progress towards implementing risk-based methods in pipeline management, research in this area has attracted more attention [1].

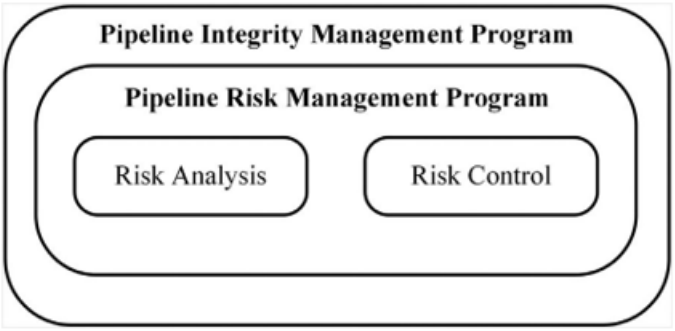

Figure 1 Set of PIMS [1]

API 1173 gives a fundamental framework for the improvement of a pipeline protection control system. Apart from its important factors associated with control, one of the key necessities is the renovation of pipeline integrity via danger control, information collection analysis, periodic review, operational controls and incident investigations. Pipeline injuries have continually been a count number of grave problems as numerous of the reviews are yearly posted for drawing attentions to pipeline-associated failure. A well-known belief is; longer the pipeline community extra is the opportunity of pipeline failure. However, with development in generation is it now feasible to control a big information bases associated with pipeline community which has helped to lessen times of pipeline failure. EGIG tenth report (EGIG, 2018) illustrates the distribution of pipeline failure per cause Figure 2 [2].

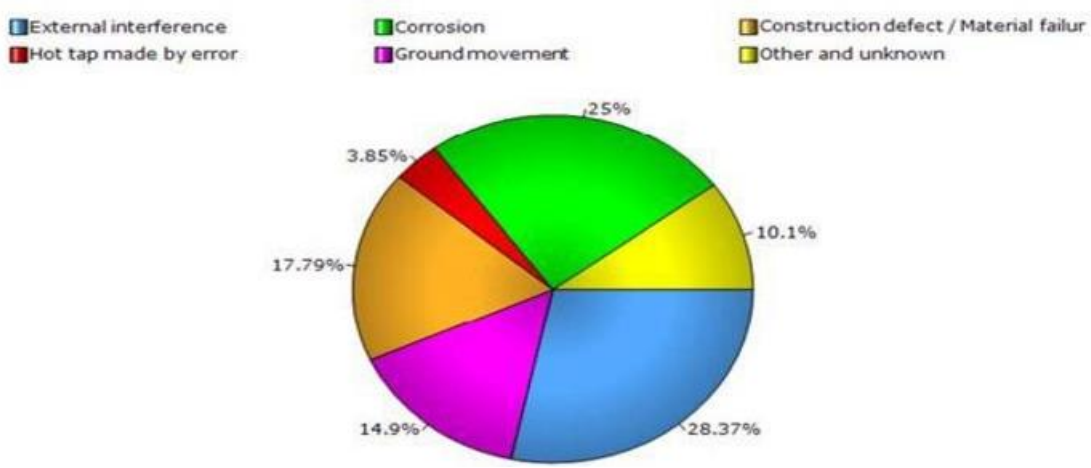

Figure 2 Pipeline failure distribution per cause [2]

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CHAPTER TWO
OVERVIEW OF ENERGY PIPELINE INTEGRITY MANAGEMENT AND FUTURE ASSET MANAGEMENT STRATEGIES

In the oil and fuel industry, control of the integrity of pipeline has increased to be an extreme commercial enterprise due to all general effect of failure pipeline: economic, social, environmental, and probably legal. Pipeline Integrity Management System (PIMS), is generated for an operational pipeline with records accumulated in the pipeline system. An evaluation of the records accumulated at the pipeline shows advanced monitoring, reliability, availability, and compliance to regulatory tips within the operation of the pipeline structures.

[3] Pipelines may also have been inspected at deliberate stages, at which period apparent troubles have been generally repaired. Systematic strategies of coping with pipelines or pipe structures is being used to provide results and invent preventive renovation or update the pipe failure occurance. The technique of solving the pipeline while it fails might not be perfect in instances wherein burst of pipe may also result in large harm to assets or damage to people, or wherein lack of the fluid could have deleterious environmental consequences. The upward and non-stop surge within side the value of supply may also compel the operator to make suitable plans to keep away from manufacturing down time because of pipeline screw ups. A pipeline integrity control software is needed for pipeline structures to boom their reliability and availability, and to successfully manipulate and reduce renovation, repair, and alternative cost over the lengthy run. Pipeline Integrity Management System is a modern technique to generate a set of flow required to record pipeline belongings for being able to supply more protection via means of minimizing threat, better productivity, longer asset life, improved asset availability from advanced reliability, decrease integrity associated running rate (cost), and make certain compliance with the regulations. Pipeline Integrity Management Systems are advanced to serve specific operational desires unusual to specific pipeline system. For new pipelines structures, the useful necessities for integrity control will be included in the planning, design, material selection, and creation of the system. However, for pipelines which are already in operation, the integrity control plan is drawn after baseline checks and records integration [3].

2.1 Petroleum and coal: An innovative approach to manage the integrity of gas pipelines: PIMS

Pipelines are one of the most crucial supply transportation arteries and are assumed to be steady device for supply transmission for decades. Among all kinds pipeline systems, gas pipelines are very crucial and vital. Due to the necessities for better protection and reliability, integrity control has grown to be a crucial programme to control hazard and expand right inspection planning. Recently pipeline integrity has shown the advent of many superior technology to discover anomalies, enhance the performance of pipeline operation and decrease failures [3]. Pipeline operators around the sector have their first goal to move commodities in secure and dependable manner. There has been a process through regulators, operators and companies to discover and mitigate any danger and expand preventive measures. Pipeline integrity may be carried out and controlled efficaciously via evaluation of various threats or risks that would result in danger to pipelines. Based on risk identification, hazard evaluation strategies may be implemented and suitable pipeline integrity tracking and evaluation techniques may be performed internally and externally [4].

2.2 PIPELINE INTEGRITY MANAGEMENT AND THE INVENT OF ANALYTICS

Managing pipeline integrity revolves around abundance of data and information from monitoring of safe operating limits, inspections and maintenance. Those data and information may come from real-time/on-line systems, manually input from inspections and maintenance carried out on a particular pipeline. Industries are perfect with respect to having a software/tool in aiding and assisting personnel in performing, repair assessments, and executing management of change for a pipeline system; and many more assessments/analyses. Nevertheless, with the invent of analytics, there is strong need to explore the new ways of working with those abundance data and information OR maximising the utilisation of the data and information for the benefit of assessing or evaluating pipeline's risk and integrity to predict 'accurately' risk and integrity so that specific and cost-effective actions and mitigations can be deployed within a stipulated period of time [5].

In those regard, PETRONAS is actively working with industry to establish predictive analytics for critical offshore and onshore pipelines' threats/anomalies i.e. internal corrosion and free span for offshore; and external corrosion and geotechnical hazard for onshore.[5] PETRONAS is leveraging on IR4.0 technologies i.e., big data analytics in order to yield more accurate prediction with respect to corrosion anomalies' dimensions and location along oil and gas pipeline. PETRONAS has taken the first step into the Analytics-based pipeline integrity management [5].

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CHAPTER THREE
DATA INTEGRATION AND ALIGNMENT – THE KEY TO PIPELINE INTEGRITY MANAGEMENT IN AN URBAN ENVIRONMENT

Pipeline's infrastructure is an important detail of supply transport structures. Its failure can have an effect on public and protection and in a roundabout way via influences at the supply. With the way of Pipeline Safety Improvement Act (PSIA) in 2002, the pipeline proprietors within the side of United States are required to make investments with a notably greater capital to look into and hold their structures. The PSIA calls for improved renovation applications and persevering with integrity inspection to all pipelines positioned, inside excessive effect regions (HCAs) in which a pipeline failure may threaten public protection, belongings and the environment. With over 165,000 miles of liquid transmission strains and almost 300,000 miles of natural gas transmission pipelines running within side the U.S. today, attempts to be essential for pipeline groups to recognize and manage the situation in their structures may be over- whelming. For this reason, it is vitally essential that pipeline operators hold accurate, included records on their pipeline gadget from creation and set up via operation, inspection and renovation. With an ever-growing variety of supply pipelines running in city environments, records series and integration turns into even greater requirement to make sure that the cutting-edge situation of the pipeline gadget is nicely understood and controlled to save from negative influences to the populace facilities that they serve. Ultimately, tendencies in records must be exploited to pick the maximum suitable evaluation methodologies and to make knowledgeable choices on in which great to dedicate assets on pipeline assets. The key to a hit integrity control application is to realize in which capacity issues lie, to recognize how excessive the issues would possibly be, and the way to manipulate those issues [6].

Pipelines positioned in city environments have precise troubles that make inspection and renovation hard for pipeline operators. Several components which might be truly precise to city pipeline structures could have an effect on the quality of the integrity evaluation consisting of problem gaining access to the pipeline, interference from overseas or different pipelines. Although inner inspections may be difficult for older pipelines structures. In addition, tracking of the cathodic protection (CP) gadget potentials have indicated a few places in which the CP potentials have been outdoor the ordinary ranges. These regions correspond with the place of excessive effect vicinity and have been highlighted as an excessive-danger place with the aid of using the pipeline operator [6].

CHAPTER FOUR
REASONS

Safety, performance and occasional cost, pipelines are extensively utilized in transporting big portions of oil and gas over lengthy distances. However, Pipelines can also additionally be afflicted by the exceptional styles of defects which includes corrosion, fatigue cracks, strain corrosion cracking (SCC), dent, etc. These defects, if no longer managed, can additionally bring pipeline disasters which includes leak or rupture, that could cause very steeply-priced downtime and surroundings hazards. [7] There are many pipeline incidents each year across the world, among which 3 of the North America pipelines incidents in 2016 led to over 2,000 metric lots of oil and fuel leak and spill. Integrity is the pinnacle precedence for pipeline operators to make certain dependable and secure operations of pipelines, for growth productivity, lessen cost, protection of the surroundings, etc. It is important to discover powerful methods to monitor, examine and guarantee the integrity of the pipeline, and decrease the danger of leaks and rupture. For pipelines, it has to be certain that safety of delivery of gas is well planned. Procedures and practices are to be carried out to protect, manipulate and hold the integrity of pipeline systems. Due to the substantial severity of pipeline disasters, the center of pipeline integrity control is to preserve pipelines in secure working conditions [7].

Due to feasible pipeline leakage, environmental harm and excessive rate of restoration and replacement, correct pipeline tracking and inspection turns into important these days. Finding and recording statistics in pipeline integrity is a step-in pipeline integrity control, and there are a number of methods to acquire facts approx. in defects. For outside corrosion in addition to different styles of threats, there are numerous inspection strategies to report statistics and for the external corrosion as well as other types of threats, there are various inspection techniques to record data on the defects [7].

Figure 3 Route for managing asset integrity [8]

[8] Other noteworthy distinctions of the gas IM rule include:

i. If an operator discovers severe corrosion on a covered segment, he must evaluate other similar segments not subject to the rule to determine whether additional action is needed. This provision increases the likelihood that information gathered by assessing covered segments will increase the integrity of all similar segments.
ii. Operators must develop and provide to their regulatory bodies data on prescribed measures of performance on a six-month interval [9].
iii. If an operator satisfies certain restrictive conditions, he may pursue a performance option that allows limited flexibility in determining the necessary reassessment interval and time to repair identified defects [9].

Incident reporting is a regulatory requirement with criteria that differs amongst regulators but with the common objective of identifying causes and preventing future reoccurrences. [9] Pursuant to section 52 of the OPR, NEB regulated companies that are required to notify the board of any incidents relating to the construction, operation or abandonment of its pipeline. Incident data is collected by regulators as a lagging safety indicator that acts as a measure for safety of operations of regulated infrastructure and to determine safety trends [9].

CHAPTER FIVE
PROPOSED FRAMEWORKS & MODELS FOR PIMS

Various models and frameworks have been made in the recent years of which some are described under this section.

5.1 Mapping safety subculture attributes

The technique used withinside the framework proven in (Fig.4) is a 3-dimensional evaluation manner of IMP and culture for safety. Conventional evaluation manner of IMP most effective assess the compliance of regulatory and standard requirements. The evaluation manner isn't able to imparting insights into the IMP effectiveness. The IMP implementation and protection are assessed in 3 different components, the compliance, severity of non-compliance, and effectiveness of the program. These components will decide the threat degree or the level of risk [10].

This framework enables the subsequent 4 objectives:

- Mapping-IMP elements with stable cultural properties [10].
- A simplified and significant evaluation of IMP and safety tradition from the angle of a regulatory agency [10].
- Risk evaluation of IMP overall performance and organizational tradition [10].
- Develop a decisive aid device for regulated audits. A simplified and significant evaluation of IMP and safety tradition from the angle of a regulatory agency [10].

The proposed model has 4 steps. The first step initiates with the identity of IMP and protection tradition necessities and culminates withinside the improvement of overall performance indicators (PI). The 2nd step entails the audits which accumulate the information of compliance to the recognized PIs. Step three makes use of the information accumulated in 2nd step to carry out a risk evaluation. In the 4th step, the risk evaluation effects are used to decide the IMP effectiveness and become aware of safety levels [10].

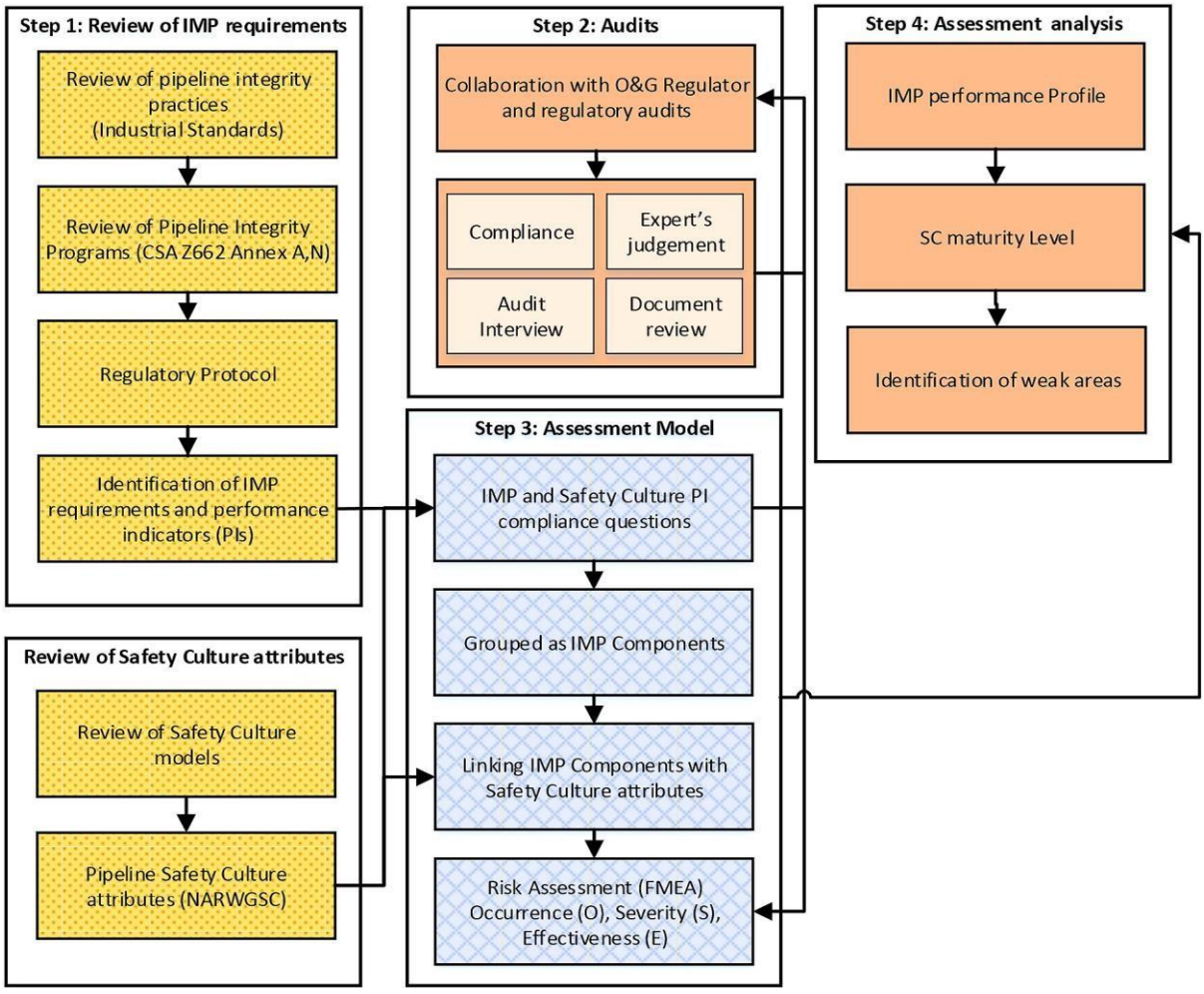

Figure 4 Safety culture attribute mapping framework & Steps [10]

The PIs are set up to evaluate the IMP overall performance from 3 dimensions, i.e., compliance, severity, and effectiveness. To investigate the compliance, the PIs are translated into evaluation questions. Their responses offer quantitative scores, which can be utilized in risk evaluation process. The evaluation questions were grouped, which can be known as IMP's parts. IMP parts are installed to offer IMP overall performance profile in consolidated form. 18 parts are identified, which can be similarly grouped into 5 higher-degree parts. The higher-degree parts offer a large assessment of IMP overall performance [10].

[10] For example, a number of the PIs, that are grouped below the IMP aspect for 'Risk evaluation', their corresponding evaluation questions are:

- Have the pipeline inventory and float connectivity statistics been reviewed, corrected, and are they validated [10]?
- Has the pipeline stock been reviewed to decide the licensing discrepancies and that suitable actions be taken to accurate them [10]?

"Vigilance" is the capacity of the origination to expect the viable failures, drawing proper conclusions from persistent facts analysis, lesson learned, sturdy fear-free verbal exchange of incidents and close to misses, conversation, and dissemination of safety awareness." These attributes may be mapped at the traits of IMP parts such as 'incident reporting and investigation', 'statistics control and conversation', 'risk assessment', 'inspection and tracking', 'assessment of inspection and tracking results', 'internal audit', 'software assessment (non-conformance)', 'control evaluation and records control'. However, the significance rating of IMP parts below the safety tradition characteristic might also additionally range from the regulator-to-regulator relying upon rules and priorities [10].

[10] The 2nd stage is regulatory auditing and records collection. The audit manner includes 3 steps:

- Compliance Questionnaire
- Document and Record Review
- Representative Interview

Next is the Risk Assessment. It is executed through novel use of Failure Mode Effect Analysis (FMEA) withinside the auditing process. FMEA transforms the qualitative information into quantitative analysis. FMEA method measures the ability causes of failures, ranks them, and prioritize mitigation plans based totally on failure phrases occurrence, severity, and detect if failure event has occurred [10].

Then comes the part of Severity Calculation. Severity withinside the model has extraordinary meanings for IMP evaluation and safety subculture evaluation. In IMP evaluation process, the 'severity' is described as an effect of failure on effectiveness even as meeting the necessities associated with a selected IMP factor. Whereas, in safety subculture evaluation, severity is measured via an significance rank and relates percentage contribution of an IMP factor closer to every protection subculture attribute [10].

Continuing is the Interpreting of risk evaluation outcomes Risk evaluation consequences are offered the use of web diagrams. The web diagrams offer a top-level view of IMP parts, and protection subculture attributes when it comes to their threat stages. Four threat stages are highlighted with the assist of various color zones. IMP parts with RPN values variety from zero to100, are taken into consideration under desirable threat sector (which is green) and display sturdy safety subculture. RPN values various from hundred to three hundred correspond to low hazard (which is mild green) with slight protection subculture; the parts on this sector are taken into consideration as moderately compliant and effective. Components with RPN values ranged among three hundred and six hundred, correspond to medium threat sector (which is yellow) with vulnerable protection subculture; essential moves are required to enhance those components. Finally, the IMP additives in better risk sector (which is red) with weakest protection subculture belong to RPN values starting from six hundred to 1000. Regulators can outline those zones as they'll alter while new rules are introduced [10].

5.2 QUALITY CONTROL IN THE PASSIVE CORROSION PROTECTION – THE COATING INSPECTOR

A quite state-of-the-art and well-coordinated active and passive corrosion safety is obligatory for a long-lasting integrity and an error-free operation of a brand-new pipeline. Furthermore, significance from an financial factor of view it's far of vital significance for the fulfilment of the target lifetime. The passive corrosion safety consists of all activities protecting the steel from corrosive media. This may be found out for example both via way of means of a acceptable plating or coating or with the aid of using constructional features. With admire of the development of buried pipelines there's an in depth technical law for all applicable applications [11].

From a technological however additionally from a cost-effective factor of view typically an aggregate of active and passive corrosion safety is implemented. Theoretically an enough corrosion safety will be performed entirely via way of means of the usage of cathodic safety, however for financial and technical motives this isn't an option. The use of a coating permits a low contemporary call for paralleled via way of means of an ideal distribution of the protecting contemporary. There is amount of necessities the coating has to fulfil, arising from the cited homes that it is essential for a purposeful corrosion safety (see Table 1). A essential difference may be made regarding the function of the corrosion safety and TPI (Third Party interference) affecting the integrity [11].

Table 1 Influencing Parameters & Requirements of Coatings [11]

	influencing parameter	requirement
corrosion protection effect	Water	low water vapor permeability
	Oxygen	low oxygen permeability
	Electrolyte	impermeable for ions
	stray current	high electric resistivity
third-party influences affecting the integrity	loading / transport / storage / handling and installation: • hit • point load • shear forces • sun light • compaction of the bedding/the soil	impact resistance indentation resistance peel strength shear strength UV-resistance
	Operation • movement in the soil • high operation temperature • aggressive soil • bacteria in the soil	adhesion and shear strength persistent versus thermal and oxida-tive aging chemical persistence microbiological persistence

Coatings are categorised into mill coatings which can be carried out withinside the plant, and field joint coatings or field-carried out coatings, which can be carried out on-site. The difference isn't most effective reasoned through the vicinity of the software however additionally the specific technical abilties in addition to specific environmental situations at some stage in the software. This reasons diverse compositions of the coatings and leads in preferred to a much less resistant field joint coating or area carried out coating with appreciate of thermal and mechanical influences [11].

A) Mill coating

[11] Depending at the mechanical & thermal necessities in addition to the geometry of the components, these days the subsequent mill coatings are used almost completely in Germany :

i. 3-layer polyethylene (particularly HD-PE) consistent with DIN EN ISO 21809-1 or DIN 30670
ii. 3-layer polypropylen consistent with DIN EN ISO 21809-1 or DIN 30678
iii. Polyurethane consistent with DIN EN 10290 (pipes, pipe fittings and valves) and DIN 30677-2 respectively

In a few cases, e.g., trenchless pipe laying, an extra mechanical safety product of fiber cement or glass fiber strengthened plastic (grp) will be mandatory. The 3 mill coating structures are followed through an improved variety of field joint coating (FJC) or area-carried out structures. This may be defined through the fact, that there should be compatible area-carried out structures for all mill coatings getting used over the past a hundred years. For example, bituminous structures had been used until the mid of the seventies as standard. Therefore, an anticipated 50 % of the German pipelines are lined with bitumen [11].

B) Field joint coatings (FJC) and field applied coatings

The class of the field-implemented coatings is normally based upon the utility system and effects in cold-implemented and hot-implemented structures in addition to spray implemented or painted systems, e.g., polyurethane or epoxy resin (see Figure 5) [11].

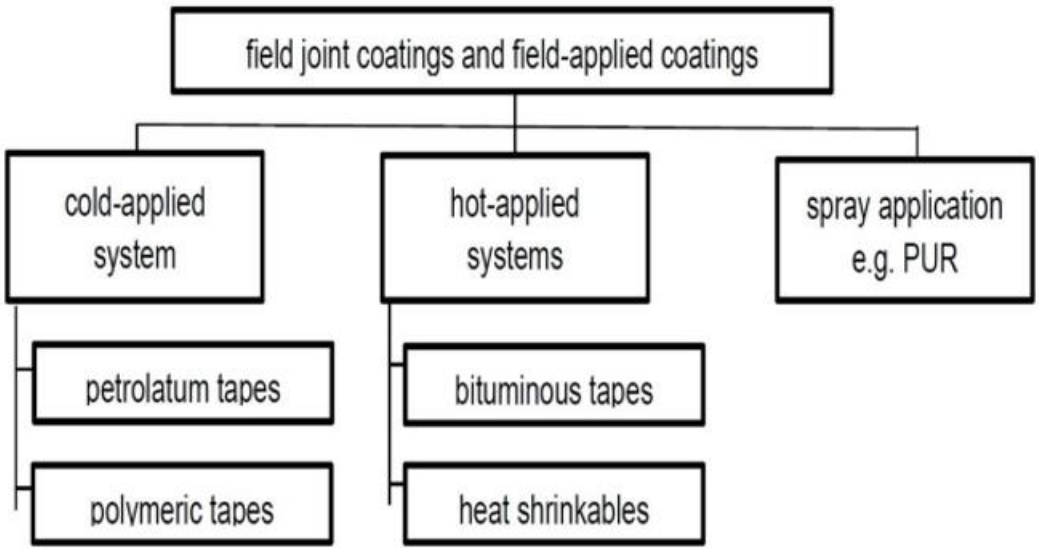

Fig 5 Classifications of the field-applied coatings & field-joint coatings [11]

In the case of the cold carried out and warm carried out substances the necessities are defined withinside the DIN 30672 and DIN EN 12068. The normative PUR requirements for field joints or field-carried out coatings do now no longer vary from the ones for mill coatings, i.e., DIN EN 10290 (pipes, pipe fittings and valves) and DIN 30677-2 respectively (fittings) [11].

C) *Conception – coating inspector and quality benchmark*

The key factors of the theory are first of all high-satisfactory benchmark/thresholds which can be fulfilled and completely skilled personnel – coating inspectors CI's-, professionals that control, take a look at and record all coating high-satisfactory applicable parameters [11]. Referring to the first concept part, the coating high-satisfactory is checked via way of means of numerous check techniques at some point of pipeline construction. A extensively used and technically smooth relevant checking out of coating high-satisfactory is the high-voltage check "holiday test", that is finished earlier than the pipeline stretches are lifted into the trench. After backfilling is finished and enough ground contact has been achieved, contemporary drainage assessments have been executed [11].

The second part of this approach is the elaboration of coating inspectors that cognizance their supervision activities solely at the coating qualities. Detailed checklists for the coating quality test were evolved and test system has been supplied (e.g., holiday tester, thickness- and hardness gauges) [11].

For example, with a view to offer extra delivery capability or the growth of present capability, the natural gas transmission pipeline from Sannerz in Hessen to Rimpar in Bavaria was constructed in 2012. The natural gas transmission LSR has a delivery capability of round 1. five million cubic meters of natural gas according to hour. It is set sixty-seven kilometers long, running from Sannerz approximately 10 km in Hessen and fifty-seven km in Bavaria to Rimpar. The pipeline is designed for an operating pressure of as much as a hundred bar and protected towards corrosion through polyethylene (PE) coating [11].

5.3 Novel Classification of Leak Detection and Third-Party Intrusion Enabling Best-In-Class False Alarm Rate

In latest years there was a developing interest in distributed fiber-optic sensing for tracking oil and gas pipelines. This progressive technology, primarily based on the interpretation of the back-scattered sign of a mild pulse that propagates alongside the optical fiber to acoustic indicators is a cost-powerful answer for pipeline tracking, particularly while mounted on infrastructure with pre-deployed optical fiber communication network. It has a highly quick ramp-up time and might cover lengthy pipelines, in a distributed manner, with a small variety of optical interrogator units. Pipeline leakage normally generates each pipeline mechanical vibrations and acoustic indicators, originate from the interaction among the leaking substance and the soil surrounding the pipeline. Both effects, the mechanical vibrations and the leak prompted acoustic indicators, may be sensed with the aid of using an adjoining optical fiber cable. Digging activity, that would threaten the pipeline integrity, creates sturdy seismic indicators withinside the ground, which are effectively detected with the aid of using sensitive optical interrogators [12].

In fact, the excessive FAR (False Alarm Rate) or NAR (Nuisance Alarm Rate) of fiber-optic sensing structures is the restricting element of the present era and is particularly originating from low records exceptional that results in inadequate type capabilities [12].

In pipeline intrusion (TPI) detection, the interest is in alerts originating from places in the direction of the monitored asset. The task that is confronted in those conditions is much less certainly considered one among risk detection, however as an alternative of

having the ability to distinguish the threats from many history alerts, originating from approved activities withinside the region of the pipeline, which includes trains, vehicles, or agriculture. Procedure harnesses the excessive SNR and the richness of the facts received via means of Hyper-Scan™ technology to extract differentiating capabilities, that might in any other case be detected by noise. These functions are then used to differentiate the threatening activities from the approved ones. As an instance, proven in (Figure 6) the sign received via means of a mechanical digger digging 10 meters far away from the pipeline. An instance of human digging the usage of a hoe, is provided in Figure 7 [12].

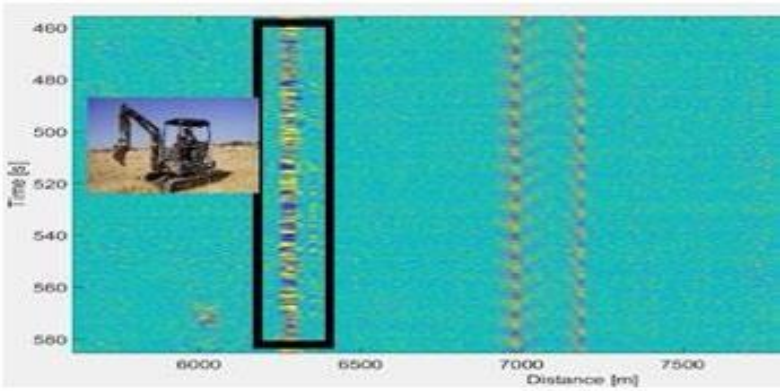

Figure 6 Signal obtained by mechanical excavator which is 10 m away from pipeline [12]

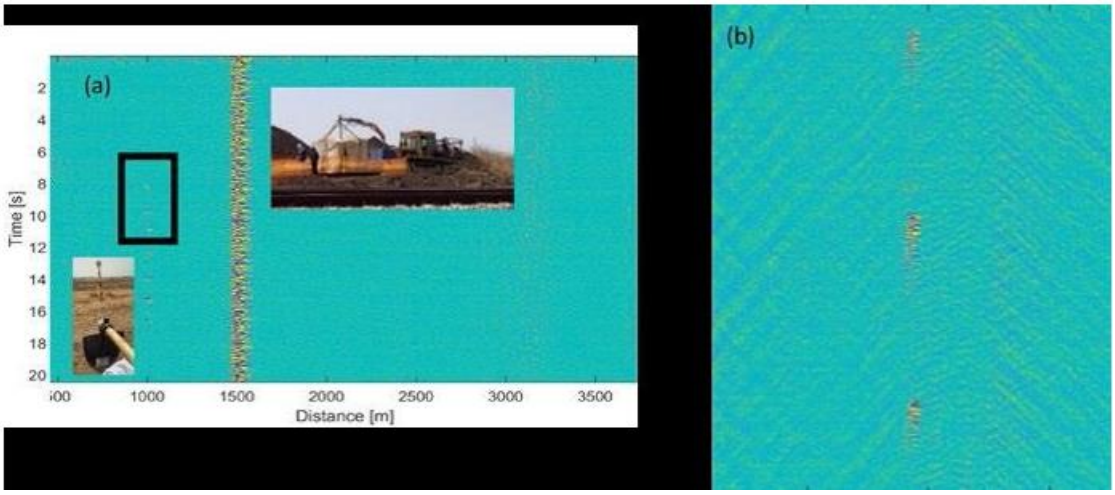

Figure 7 Signal via human digging using a hoe [12]

5.4 Versatile technology for Leak Detection, Third Party Interference and Integrity Assessment applications: Vibroacoustics

Leak detection (LD), Third Party Interference (TPI) and asset integrity are essential topics in pipeline monitoring, despite the fact that they frequently require high priced strategies and systems. In order to assist the pipeline integrity management, Eni S.p.A, in collaboration with Solares JV, advanced the e-vpms® (Eni Vibro-acoustic Pipeline Monitoring System). This technology, patented via way of means of Enis SpA, turned into particularly designed to hit upon influences and spillages on Oil & Gas pipelines, unlawful tapping and precursor events, however additionally to be able to performing general-cause integrity evaluation tasks. The evolution of the system, in phrases of sensor sensitivity and algorithms, brought about the improvement of a effective software program module for the TPI detection, category and localization. This model is capable of carrying out the recognition of the preparatory activities preceding the unlawful tapping, inclusive of digging operations [12].

The e-vpms® is a multipoint community of vibro-acoustic sensors set up at the pipeline at a variable relative distance, typically 10s of kilometres (see figure 8). The vibro-acoustic wave- subject is a mixture of sound, pressure and vibrations, which if used collectively and on the identical time can offer deep and extensive facts to locate a huge kind of physical phenomena. Whenever whatever happens, acoustic and elastic waves are generated from the supply region and travel at the rate of sound in each directions; the vibro-acoustic sensors report such waves and a significant processing unit offers the alarm, collectively with the region and class of the triggering event wherein feasible [12].

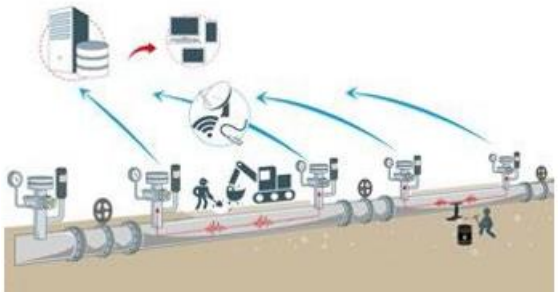

Fig 8 Multi-point network of vibrating- acoustic sensors [12]

The vibro-acoustic wave-subject produced via means of any sort of mechanical interactions reaches the sensors, that send statistics to a centralized processing unit liable for alarm notification. When vibrations produced via means of digging activities takes place at the pipeline, a perturbation of the vibro-acoustic wave-subject travels alongside the pipeline attaining the e-vpms® sensors. When a spillage takes place a perturbation of the vibro-acoustic wave subject run in the pipeline attaining the e-vpms® sensors (see Figure 9) [12].

Figure 9 A evpms® sensor [12]

Mainly, the machine processes pressure waves, which might be already broadly used withinside the enterprise to discover leakages in lots of conditions. Dynamic pressure statistics permits each detection and correct localization, however the vibrational element iscontinually present specifically at the pipeline shell. It travels at the rate of elastic waves for lots of kilometers, despite the fact that could be very tough to discover and its detection requires very sensitive gadget and superior strategies of signal processing. Pipes are efficient wave-guides for sound transmission; due to this, sounds and vibrations may be used to track many phenomena that aren't detectable through a easy pressure-primarily based machine. So that the pipe acts as a perfect wave-guide, it have to be filled of fluid at a minimal pressure of one barg. Regarding to regular sounds withinside the pipe, the e-vpms® also can use the pump noise as an energetic acoustic supply to carry out precise tasks, or, through approach its patented adaptive noise removal, it is able to make certain the best-inclass SNR (Signal-to-Noise Ratio) to strongly enhance the overall performance of leak or effect detection [12].

Currently e-vpms® is served in foremost types. The first one is referred to as LD, which stands for leak and effect detector. It can locate impacts, leaks and a few precursor occasions or preparation activities, which occur commonly earlier than the unlawful tapping. In this configuration, the everyday distance among sensors is from 15km to 30km in liquid, and 5km to 10km in gas; in decided on scenarios, like for offshore installation, the gap may be as much as 50km. The device can carry out many different things, inclusive of PIG tracking, asset integrity and failure detection [12].

TPI alarms whilst the unlawful event is registered with the aid of using one station or as a minimum station. In the primary case, the yellow alarm is raised and simplest the detection may be performed. In 2nd case, the orange alarm is raised and an correct and specific localization of the supply of vibration may be provided.(see figure 10) [12].

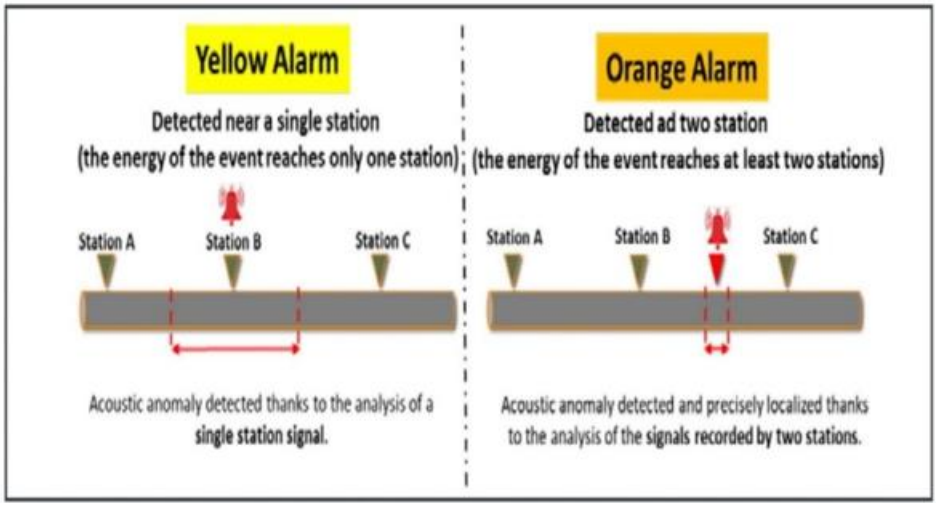

Fig 10 Alarms in different cases [12]

5.5 APPLICATION OF PROACTIVE RISK MANAGEMENT IN PIPELINE INTEGRITY

Risk control is an crucial element withinside the pipeline integrity management process. Risk control entails not most effective the estimation of risk profiles and contrast towards tolerable criterion however additionally making sure that measures to deal with the risk are successfully assessed and implemented. Performing threat checks can help operators and engineers in information important issues. If danger is controlled proactively in place of reactively, operators have to be capable of observe preventative and mitigative measures early sufficient to prevent pipeline failure from occurring. In addition, adopting a proactive/preventative method might permit sources to be successfully applied for the optimization of upkeep plans. Enabling such tests calls for an powerful risk model, consequently efforts are centered on modelling and estimating the danger of pipeline failure in a quantitative way. Such frameworks may be quite complex, detailed, and require huge quantities of statistics integration; in addition, they want to generate threat elements in a constant and transparent way to help powerful selection making [13].

ROSEN's Quantitative Pipeline Risk Assessment Model (QPRAM) turned into advanced to cope with the expectancies and demanding situations inherent in figuring out and assessing risk factors. QPRAM carries probability, consequence, and risk factors right into a modular framework, and lets in flexible construction of custom designed models to reflect particular programs inclusive of pipeline location, fluid type, records availability and required degree of complexity [13].

QPRAM affords a common framework (see figure 11) for comparing the probability of failure because of credible threats via means of assessing the historic failure frequency of the pipeline system with a aggregate of mechanistic, operational and environmental situations. The version assesses the severity of situations that would have an effect on the pipeline's integrity degradation, and compares the severity towards the first-class and effectiveness of passive and active preventative and mitigative measures. Inspection data (which include from an smart inline inspection) and related assessments (which include fitness for service) offer especially correct records concerning presence, size, and criticality of anomalies withinside the pipeline, which in flip may be used to deduce the presence and severity of the active risk withinside the line. This data (if to be had and relevant) is then in comparison with the changed failure frequency to generate a elegant failure frequency profile alongside the pipeline. The end result is a particularly special profile of the (changed) or refined failure frequency values displaying the variant relative to historic frequency. Thus, regions of the pipeline are recognized which might be greater or much less likely to fail than average (baseline) and via means of how much [13].

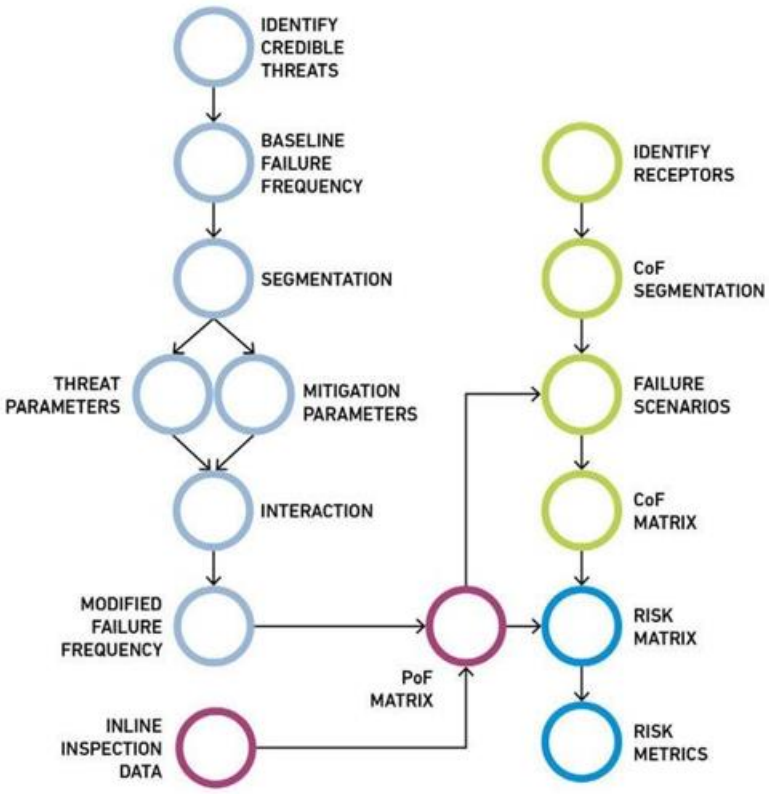

Figure 11 QPRAM's Framework Model [13]

5.6 Operations & Integrity Management and Compliance in an age of IIOT

There are about four million miles of pipelines spanning a few one hundred twenty nations throughout the globe, with oil, gas and different probably risky fumes and gases. The pipelines go deserts, oceans and a number of the maximum inhospitable environments recognized to man. Honeywell have supplied manipulated structures for pipelines for over 30 years, and now we see how IIOT is being utilized by Maintenance and Operations body of workers with improvements together with Intelligent Wearables to convey plant important records returned to a valuable place and the way it is able to be analysed and used to make the proper selections expediently. UAVs are actually getting used to hit upon hairline fractures in pipelines, in addition to imparting high-decision pics to help with safety and preservation procedures [11].

[11] Technology that has come to the fore in latest years is the UAV or 'Drone'. Originally visible as a novelty, the improvements together with raise generation, GPS, gyroscopic stabilisation, 4k digital digicam miniaturisation and lithium battery generation and, most significantly of all, the smart software program advances, have intended that those devices are actually used for a whole lot of business programs, together with: -

- Pipeline Inspection
- Crack detection
- Maintenance inspections
- GIS mapping
- Flare stack inspections

This generation, with inside the arms of skilled pilots, alongside the proper analytical software program is attracting new customers each week, making operations safer, proactive and extra cost-effective, in addition to streamlining preservation workouts and imparting get right of entry to to topographically and geographically hard terrains. Layered defence is the satisfactory approach: the usage of superior risk intelligence; stay danger control reporting on Network & Endpoint safety, Patching and Back-up repute and bodily check pointing of hardware all subsidized up with the aid of using an over-arching far flung Security Operations Centre. Traditionally far-flung operations have been the keep of customers with pipelines belongings in uninhabitable or difficult to attain locations. There is now a actual push to discover offerings and programs in datacentres (both controlled with the aid of using third-events like Microsoft or with the aid of using the patron themselves), that is pushed with the aid of using the shortage of IT assets had to manipulate the server infrastructure, along with patching, upgrades, preservation and restore or to capitalise on tons decreased CAPEX expenses concerned in a far flung installation, who prefer rather to transport to a predictable SaaS model [11].

The (fig. 12) indicates us what's going on now, we will use Collaboration Stations to proportion ideas, records-sheets, P&ID's and stay video streams to examine pipeline operations in actual- time and make sound commercial enterprise selections unexpectedly the usage of the maximum up to date statistics. If we then couple this with intelligence, we will import from Wearable Solutions alongside enter from professionals who also can get right of entry to the stay records remotely and offer enter through Skype or different video streaming tools, we will begin to see how the Operator actions toward a Business Operator function due to the fact they have got the appropriate statistics, on the proper time with the satisfactory analysis, letting them pass from a reactive to proactive/predictive operational standpoint [11].

Intelligent Wearables had been followed with the aid of using some of essential Oil & Gas companies, the capacity to train, keep and tell in actual-time is visible as a primary gain and, in line with unbiased research, is welcomed with the aid of using the 'Millennial Generation' who call for on the spontaneous statistics get right of entry to and had been confirmed toreply properly to this transport technique in place of the conventional school room approach (which nevertheless has an area for positive trainees). Trial programmes are once more to be had and the variety of product and answer schooling we provide is developing all of the while [11].

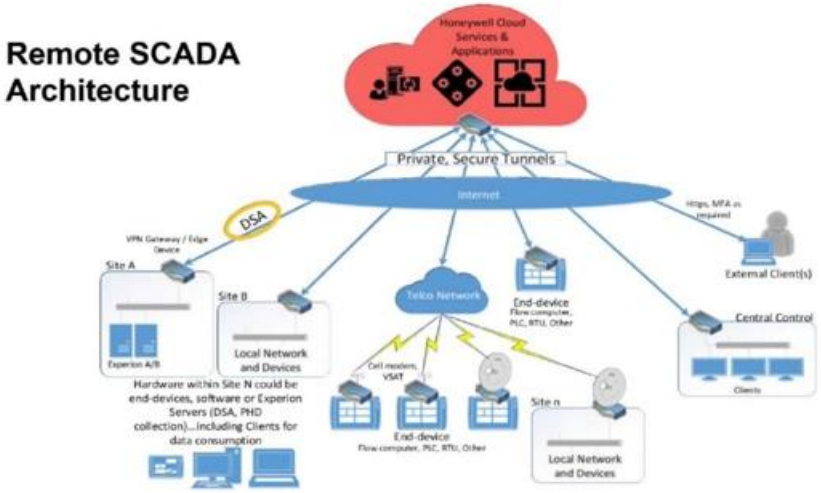

Fig 12 SCADA Remote Structure [11]

Owners of oil and gas pipelines want to realize that the maximum essential factors of a safety program (each bodily and digital) are figuring out enterprise risks, being proactive, embracing a safety philosophy, and growing a long-time period method that eliminates (or reduces) ability threats. In order to guard their structures and networks, pipeline operators require a complete method to new technology, cyber safety and revolutionary adoption regulations which includes ongoing chance assessment, well-described safety regulations and a competitive standard safety posture. This will cause more secure working and running environments, decrease OPEX expenses and elevated margins if applied successfully [11].

5.7 Lessons Learned on 20 years of challenges to internal corrosion protection of subsea pipelines-corrosion inhibitor or pH stabilization?

Depend at the mode of protection, there are numerous problems and demanding situations which danger the pipeline integrity and waft assurance. One of the current primary problems is possibly danger on TOLC (top of line corrosion) initiation in segregated waft regimes, wherein excessive quantities of acidic gases (CO2 / H2S) are dissolved within the condensed water because of the cooling with the aid of using outside conditions (excessive warmth switch rate). On the opposite side, at the lowest of pipeline there's a danger for Corrosion Under Deposit (CUD) wherein natural depositions is in all likelihood and inhibitor diffusion is minimal. To address this issue, compliance to diligent software is in development to run bi- directional or sphere pigs to mitigate the corrosion danger with the aid of using getting rid of the sludge, deposit and liquid hold-up from the pipeline [12].

PST

[12] PST (Ph stabilization technique) could be very properly applicable for use in mixture with glycol as hydrate preventer which regenerated in a closed loop which taken into consideration fee powerful from operational cost factor of view. The position of PST is shooting H+ ions and therefore growing bicarbonate attention and decrease the fluid corrosiveness. However as primary obstacle and drawback, while the formation water incorporates excessive concentrations of calcium cations (above 500 ppm), the capability for calcium carbonate sedimentation will increase appreciably because of the increment within the insoluble calcium carbonates which skilled in South Pars. Below equation indicates the equilibrium response for calcium carbonate formation:

[12] H 2CO3 <-> H+ + HCO3- Ca++ + $HCO3^{-}$->CaCO3 + H+

Consequently, it become sincerely understood that a unique caliper pig device is needed to skip within the pipeline on the subject of the size significance. The configuration for the 32" caliper pig used had sixteen caliper palms and odometer distance dimension wheels. The sixteen caliper palms activated eight caliper sensors, i.e., palms to every sensor. The purpose of the caliper survey become to document the location, and approximate quantity, of calcium carbonate deposits shaped in the pipeline as an undesirable a part of PST [12].

To dissolve the size, a big operation of acid cleansing completed via way of means of injection of inhibited hydrochloric acid among pigs the use of pistoning method and acid withdrawal via way of means of depressurizing and next neutralization via way of means of soda ash [12].

Another problems with PST, is sludge deposition because of infection of glycol with salt, hydrocarbon, particulate, or corrosion inhibitor. These contingencies boom the fee for changing glycol filters factors and additionally renovation crew to war to satisfy the timing compliance. In worst case scenario, if the glycol gadget is improperly contaminated, the gadget is to be absolutely tired and recharged with new sparkling glycol. Under this instances it's miles strongly required a MEG reclaiming bundle to be established as complementary of MEG regeneration unit [12].

Corrosion Inhibitors:

Continues injection of former inhibitors has been taken into consideration as a backup corrosion prevention technique of sea lines. Proper corrosion inhibitors decided on via way of means of a extensive variety of laboratory and area evaluations. A variety of things which include temperature, pressure, inhibitor water-condensate partitioning, water chemistry and float regimes have an effect on inhibition in multiphase float pipelines. Severe localized corrosion detected on comparable zones wherein water saturated gas is trapped as like TOLC. One method to this problem, is float sample enhancement which allows C.I molecules to connect all pipe wall surface. Unfortunately, the most effective potential method to come across metallic loss because of TOLC is ILI which isn't a common software to seize the danger in early stages. Consequently, a diligent dynamic takes a look at technique is needed to assess inhibitors overall performance on prevention of TOLC. Finally, for the reason that CI are typically now no longer surroundings pleasant and can't be disposed within the surroundings, maximum stringent precautions and care is needed for secure disposal of inhibitor solutions because of the safety of any environmental facet impact like converting the biochemical oxygen call for and chemical oxygen [12].

PST calls for costly capital funding even as CI imposes extra walking prices and additionally offshore logistic expenses. In addition, there may be constantly chance of C.I unavailability because of terrible climate or different dispatch problems. Mostly, there may be no sufficient area on systems to preserve big chemical inventory [12].

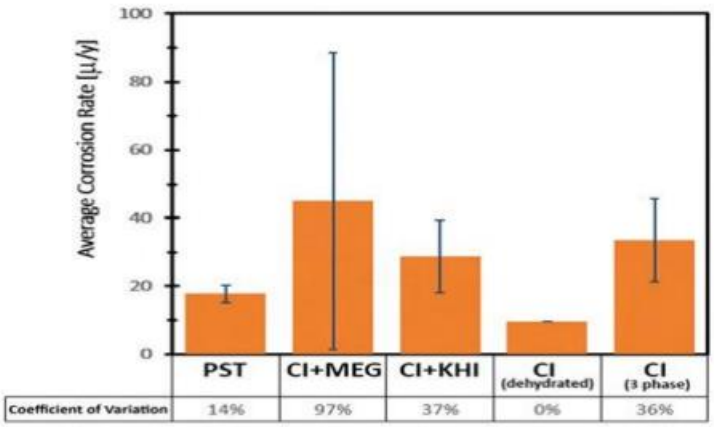

Fig 13 Corrosion rate measurement by coupons and ER probes for both methods of CI injection and PST [12]

5.8 Maintaining pipeline integrity through holistic asset Management

The holistic asset control method is a scientific method that gives an incorporated view of the EAM gadget inside the complete organisation's control gadget. It is an powerful manner of dealing with belongings utilised through an organisation, via their lifestyles cycle, for the motive of cost advent and delivery. This is plain from the EAM gadget's definition: "The gadget that plans and controls the asset-associated supply and their relationships to make sure the asset overall performance that meets the meant aggressive method of the organisation". As such, EAM consists of each technical and commercial enterprise supply of an organisation. As a manage gadget EAM entails a hard and fast of making plans and manage supply at exclusive organisational tiers. Its span of manage extends from identity of the want to the disposal and legal responsibility thereafter. Thus, asset control supply want to be organised through specializing in lifestyles cycle value and all asset-associated organizational interrelated via all lifestyles cycle stages. For example, choices at the disposal of an asset in addition to choices at the advent of recent belongings are interrelated. This calls for contributions from many organisational entities and tiers in exclusive lifestyles cycle stages [14].

[14] Areas wherein the reaction of pipeline businesses to the want to manipulate pipeline integrity include:

- extracting, sorting and formatting the to be had records right into a database for boosting the EAM choice making process.
- incorporating the present records to be had to pipeline operator into an incorporated choice guide gadget
- growing the EAM guide choice fashions to beautify trade-offs or options contrast choices
- incorporating lifestyles-cycle value and danger evaluation strategies knowledgeable through expected overall performance for asset choice making. While a few easily to be had gear can be employed, it'll be vital to increase and adapt to be had gear via studies a good way to completely comprehend the advantages that can be obtained [14].

5.9 A Multi-Position Approach in a Smart Fiber-Optic Surveillance System for Pipeline Integrity Threat Detection

Pipeline transmission is used as a transmission technique to move the power reassets primarily based totally on liquid or gas from the manufacturing factories to the very last users. Special interest is wanted from the manufacturing unit operators with a purpose to save from accidents that may cause human deaths. Moreover, maximum incidents across the factories associated with natural gas transmission take place while the pipelines are broken with the aid of using works completed of their surroundings. Therefore, cost-powerful answer improvement taking into account constantly tracking suspicious supply that constitute critical threats for the pipeline is a need. Distributed Acoustic Sensing (DAS) generation may be successfully implemented to this task, in view that this lets in to constantly interrogate city regions with the aid of using measuring the interest taking place close by a fibre-optic buried below the ground. Moreover, phase-touchy Optical Time Domain Reflectometry (φ-OTDR) in fibre-optics has been appropriate DAS generation: Conventional φ-OTDR-primarily based totally sensors can experience numerous tens of kilometres, with spatial resolutions of some meters, and were proven to offer sufficient sensitivity to permit the detection of simulated signals and those on foot over a buried fibre. The machine integrates exclusive modes: system + interest identity and chance detection. In the primary mode, the entered acoustic sign is assigned to a sure system + interest pair. In the chance detection mode, the sign is surely assigned the chance or non-chance class. The first mode is good for conditions wherein each the system and the interest completed have to be known. The 2nd mode is good for instances wherein only a chance for the pipeline have to be detected [15].

5.10 The Use of Deep Neural Networks for Automating the Detection and Classification of Pipeline External Damage

Pipeline and equipment used in oil and gas production and processing systems are regularly exposed to various damage mechanisms including corrosion, cracking, fatigue, and erosion. Such damage mechanisms cause the gradual degradation of the operational lifetime of the equipment, which can lead to multiple failure events such as leakage, rupture, and burst. The inability to control degradation mechanisms may yield significant detrimental impact on the safety of the personnel as well as the sanity of the environment and can impose a huge financial burden on the organization. Also, to comply with the safety guidelines required by the government, asset owners are required to carry out inspection surveys to ensure the integrity of all their pressure-containing equipment. Therefore, regular or risk-based inspection practices are of utmost importance to the management of asset integrity, making such practices crucial to both the safety of oil and gas production operations as well as their jurisdictional and economic viability. Asset owners are required by the government to carry out regular inspection surveys to ensure the integrity of all pressure-containing equipment. Conventionally, such operations are performed manually by teams of trained inspectors through visual examinations on-site or remotely. Decades of survey videos captured by remotely operated vehicles (ROVs) and drones are broken into frames with optical character recognition (OCR)-extracted time/location stamps, which are annotated inspectors to precisely delineate the boundaries of the damaged areas and their specific categories. After extracting images from videos, augmenting the image data, the training set is fed into a deep convolutional neural network architecture equipped with instance segmentation layers for object detection. Trained models are then deployed on the cloud acting as intelligent inspectors for future surveys, allowing also to balance the trade-off between the inference accuracy and performance speed, being crucial to real time usage of the software [16].

5.11 PICA: PIPELINE INTEGRATED CORROSION ASSESSMENT TOOL FOR STRUCTURE INTEGRITY

As in-line inspection technology advances and tool resolution and accuracy increase, the traditional methods of dealing with ILI data are quickly becoming unfeasible, both from an economic and a practical point of view. Corrosion growth analysis provides a proactive method of analysing large quantities of ILI data, prioritizing pipeline repair programs and optimizing re- inspection intervals. It enables operator to fully understand the potential future risk to a pipeline due to corrosion (Desjardins, 2002). There is thus a need to provide the pipeline industry with an effective and affordable approach to assess corroding pipeline, and in particular, a need to effectively manage the vast amounts of collected data relating to pipeline condition, in a way that enables pipeline operators to maintain pipeline integrity [17].

PICA integrates deterministic and reliability method to evaluate the time-variant remaining allowable pressure of steel pipelines subjects to internal and external corrosion based on series of metal loss data. The deterministic assessment method is preferred by pipeline operator due to its simplicity, yet the accuracy is still arguable as the integrity of assessment results is dominantly governed by inherent uncertainties which insufficiently covered even by the introduction of safety factor. Whereas reliability assessment requires systematic data sampling and matching method as well as probabilistic nature of the parameters to give more credible and accurate result especially in estimating the corrosion growth rate. The combination of data sampling, data analysis, structure assessment and integrity prediction both in the form of deterministic and reliability-based methodology has great potential to be developed as robust and potent software. This assessment software covers wide range of options including selection of

assessment codes, corrosion models, data sampling techniques, assessment methods and particularly effective to manage the vast amounts of collected data relating to pipeline condition, in a way that enables pipeline operators to monitor the pipeline integrity efficiently. The framework of PICA procedure consists of four independent stages namely data sampling, data analysis, structure assessment and integrity prediction. Every single stage was developed as a standalone component with specific output. Even so, all stages are later integrated to give a comprehensive assessment option to pipeline owner if failure probability of the line becomes the preferable main output .By integrating various stages of pipeline assessment procedure into a unified systematic assessment framework, it can greatly assist pipeline operator to protect the public, financial investment and environment from such devastating effects owing to pipeline failures [17].

5.12 PIPELINE HEALTH INTEGRITY MONITORING (PHIM) BASED ON ACOUSTIC EMISSION TECHNIQUE

The AE (Acoustic Emission) method lets in managing the harm as S-Flaws (Superficial flaws) took place all through service operation of notable zones of metal (steel) components, tracking the initiation and the propagation of essential defects, submitted to static or variable stresses and competitive surroundings exposure. In the framework of the fueloline &power studies challenge orientated to the improvement of a "AE methodology" for tracking essential sections of fueloline transmission pipelines, a observation has been achieved at the same time with (CSM), aimed to research reliability and applicability of the AE method to steels used withinside the Oil &Gas industry. Grades of Steel according API 5L X65, X80 and X100, representative of conventional and new fueloline pipelines, were selected. The task became scheduled investigating the ability of those steels for releasing elastic waves generated with the aid of using sources of damage associated with ductile or brittle fracture mechanisms. Hydraulic assessments till failure have been accomplished on single pipes the usage of metal grade API 5L X65 for tracking the developing of the damaged at the tip of synthetic surfaces notches (S-flaw), machined at the wall thickness. Water turned into used as internal fluid and temperature impact consideration as well. The functionality of the AE method to discriminate ductile and brittle fractures, the crucial statistics to approach an integrity evaluation procedure, became achieved. [18] The Acoustic Emission method permits taking under control the risk propagation in crucial zones of the pipeline which turned already investigated the usage of the "pig inspection". In case of the operation reliability of the pipeline have to be satisfied, the AE approach may be used for non-stop tracking of crucial defects. From the view point of structural integrity of pipe the overall performance of the AE approach ends in a type as "dynamic inspection". In reality the Acoustic Emission approach is efficient for use as a ND approach for tracking the reliability of a pipeline in service, submitted to static or variable stresses and competitive surroundings exposure [18].

Over the beyond few decades, recurrent pipeline fail has induced a chief effect on human lives and assets damage. Studies have proven the shortage of a comprehensive, integrated, and available set of risk-knowledgeable integrity control frameworks and equipment for pipeline operators are the primary cause behind the damages [18].

5.13 System-level prognosis and health monitoring modeling framework and software implementation for gas pipeline system integrity management

Over the past few decades, recurrent pipeline failures have caused a major impact on human lives and property damage. Studies have shown the lack of a comprehensive, integrated, and accessible set of risk-informed integrity management models and tools for pipeline operators are the main reason behind those damages. To address this gap, a system-level Prognosis and Health Monitoring (PHM) modelling framework for gas pipeline system integrity management to prevent or reduce the likelihood of failures. PHM modelling is a comprehensive approach that takes into consideration all possible failure modes of the pipeline under study. It leverages the advancement of sensor technology to stream field data in real-time to perform a dynamic system- level failure analysis based on Hybrid Causal Logic (HCL) and Dynamic Bayesian Networks (DBNs) predictive models to provide cost-effective and optimal mitigation actions such as sensor placement and maintenance schedule optimizations. The developed models are implemented into a software platform where the pipeline operators can observe the real-time and projected health state of the pipeline and the set of suggested actions to enhance the structural integrity of the pipeline system. The platform includes three main modules: Real- Time Monitoring, System-Level Reliability, and Optimal Mitigation Actions. From a safety perspective, the proposed comprehensive and dynamic pipeline health assessment framework either prevents the pipeline failures or reduces their likelihood by supporting pipeline operators in optimal decision-making and planning activities. Energy-related pipelines can carry natural gas, consisting mostly of methane, oil, and certain other hazardous liquids. In order to transport natural gas from production to the consumers, different pipelines and lines are used namely gathering, transmission, and distribution pipelines. Production lines are used to produce the gas from the production wells, either from onshore or offshore sites. Once the gas is produced, gathering pipelines carry the gas from the wellhead to a processing and treatment plant. Following refinement, transmission pipelines are used to carry the gas to the city gate. Transmission pipelines have the longest length since they move the gas around the country.[19] In the US, there are more than 300,000 miles of gas transmission pipelines. They also operate under the highest pressures (200–1500 psi usually). Once the gas reaches the city gate, distribution pipelines that operate at a lower pressure (up to 200 psi for gas mains and up to 10 psi for residential service lines) are used to deliver the natural gas to individual homes, commercial customers, or industrial plants [19].

5.14 A hybrid model of internal pitting corrosion degradation under changing operational conditions for pipeline integrity management

Amongst different failure mechanisms, corrosion is especially significant for oil and gas pipelines, and pitting corrosion is one of most concern because of the high pits growth rate. [20

]15% of all transmission pipeline incidents in the United States and 58% of oil and gas pipeline failure in Alberta, Canada, were due to internal corrosion Furthermore, 90% of corrosion failures of transmission pipelines in the United States between were due to localized corrosion. Therefore, investigation of internal localized corrosion is an essential task in pipeline integrity management. While there has been significant progress in understanding uniform corrosion, localized corrosion is still not well understood [20].

Although pipelines are the most reliable and economical mode of transportation of oil and gas in large quantities, their failures and maintenance activities can impose a high cost to industry.

In order to avoid unpredicted failures and also unnecessary maintenance activities, having a high estimation of pipeline degradation due to different potential failure mechanisms is critical in pipeline integrity management. Therefore, investigation of internal localized corrosion is an essential task in pipeline integrity management. While there has been significant progress in understanding uniform corrosion, localized corrosion is still not well understood. Some of these parameters are pH value in the water phase, the water chemistry, the protectivescale, the CO2 partial pressure, the amount of H2S, the effect of oil wetting, the metal alloy composition, the temperature, the multi-phase flow, and the flow rate. In addition, there is temporal and local heterogeneity in some of these parameters, and interdependence between them. There has been some progress on development of different pitting corrosion degradation models in the literature. The proposed framework is founded on two Bayesian inference techniques: augmented particle filtering (APF) and HB methods. APF is used to fuse online inspection (OLI) data and estimate the degradation level of the reference pit. A HB method is used to fuse ILI data and estimate degradation level of ILI pits at ILI times [20].

5.15 The application of Internet of things technology in integrity management of urban gas pipe network

On the Internet of things technology in the gas pipeline integrity management the present situation of the study is less. The integrity management system of urban gas pipe network based on Internet of things technology is proposed, and the main application scenarios are analysed. The results show that the application of Internet of things technology improves the uniformity of data collection in pipe network operation management, promotes the sharing of data, and avoids multiple data conversion. The detection results of various sensing means, methods and instruments can be integrated to ensure the reliability of risk assessment and integrity assessment. City gas pipeline networks are generally located in densely populated and commercially developed urban core areas, once a safety accident occurs, the impact and loss will be huge [21].

[21] The concept of the Internet of Things was first proposed by the AUTO-ID Centre at the Massachusetts Institute of Technology (MIT) in the United States, and there is no clear definition yet. Nowadays, it usually refers to a new network structure that connects various information sensing devices and operating devices that used to work independently through the Internet, and uses the Internet and traditional telecommunication networks as the information carriers to enable each device to operate in a unified converged state. Compared to the Internet, Internet of Things can not only deliver real- time and accurate information about objects and processes; meanwhile, Internet of Things can sense and collect information and data in real time, and analyse and intelligently process the information and data obtained, so as to achieve intelligent control of objects and make them more intelligent. Gas enterprises can apply the Internet of Things technology to conveniently evaluate the effectiveness of the existing integrity management system, and according to the corresponding results, gradually improve and perfect the integrity management methods and improve the management level [21].

Unlike long distance pipelines, the city gas pipeline network has many potential safety hazards in its design, construction and management due to its diverse investment and operation entities and different construction cycles. In addition, the gas pipeline network mainly serves the densely populated, commercial activities, construction of frequent, economically developed urban areas, in the event of a safety accident, it will cause serious casualties, economic losses and adverse social impact. Therefore, it is particularly important to carry out integrity management for the city gas pipeline network. The integrity management of city gas pipeline network is through the comprehensive collection and combing of city gas pipeline network data, and then systematically identify and evaluate the risk of pipelines, so as to prevent safety accidents and ensure the safe and reliable operation of the gas pipeline network process [21].

5.16 A Review of Vibration Detection Methods Using Accelerometer Sensors for Water Pipeline Leakage

In recent decades, water companies have increased the efficiency of their distribution systems because of the increasing demands of the public and industry for treated water. Consequently, in most countries, engineers and researchers have developed leak detection techniques to address leakage problems in water pipeline systems. Water pipeline leakage detection techniques and categorized them into software-based, hardware-based and conventional methods. A software-based method uses various types of computer software to analyse the measured data from internal pipeline parameters, such as pressure, flow rate and temperature. Meanwhile, a hardware-based method detects leaks by visual observation or using right measurement equipment. On the other hand, a conventional method or traditional method relies on experienced personal walking along the pipeline and looking for unusual

patterns of door or noise near the pipeline [22].

5.17 Structural Integrity Assessment Of A Pipeline Subjected To An Underwater Explosion

Various trunk lines pass both regions which withinside the current past had been war theatre or dumping regions used for burying guns after the final battle. The presence of unexploded mines, bombs at the seabed constitutes a capability threat for the structural integrity of submarine pipelines. Before laying, it's miles consequently important to take away the unexploded costs inside a corridor along with the route. Risk nonetheless stays at some point of the pipeline life, in view that annual surveys can display evidences of unexploded mines dragged via way of means of fishing gears until the sticking out pipeline. Consequently, the structural integrity evaluation of a submarine pipeline subjected to underwater explosions is of the maximum importance [23].

UNDERWATER EXPLOSION BEHAVIOUR: An explosion is a chemical response which converts the explosive material right into a greater solid product, in preferred a fuel line characterized via way of means of very excessive temperature (~3000°C) and top pressure (~15-25 GPa), with an exceptionally speedy manner. Once initiated, the chemical transformation takes place so hastily that a completely slim boundary is evolved among the material withinside the preliminary circumstance and the product of explosion. The strolling discontinuity, known as the detonation wave, is continued from the launched energy of the chemical method and travels at a pace of 6000-9000 meter per second, relying on the character of the explosive. When the detonation wave arrives on the boundary of the charge, the encircling water is loaded with the aid of using a stress wave impulse which exponentially can decayed in few milliseconds. This stress wave is characterized with the aid of using a totally steep front which propagates radially outwards withinside the compressible water. The preliminary stress in the fueloline sphere is a whole lot better than the water hydrostatic stress, inflicting the encircling water to be subjected to a huge outward acceleration because of the speedy enlargement of the gas [23].

5.18 IMPAKT: Oil and Gas Pipeline Integrity Management Program Assessment

Pipelines are most known because the maximum practical and cost-powerful mode of transporting oil and gas and now have been the maximum dependable part of worldwide energy infrastructure. In North America, the O&G pipelines offer fundamental infrastructure to move petroleum merchandise each for upstream and downstream sectors. Pipelines' secure protection and operation are important to make sure the minimums hazard to the general public and the environment. Regulatory government require operators to increase and put in force pipeline integrity control packages (IMP) according with relevant enterprise standards. Integrity tests are common equipment to make sure compliance with particular regulatory requirements. The conventional IMP evaluation is the maximum practiced technique which ascertains compliance however does now no longer always offer statistics software effectiveness. Effective software is proactively conscious of the emergency conditions. The proposed model, the integrity control software evaluation and expertise tool (IMPAKT), systematically captures the evaluation effects and evaluates the effectiveness of the operator IMP packages the usage of quantitative threat evaluation and the first-class control gadget approach. The model offers a base for destiny compliance and aggressive overall performance benchmarking of the operators withinside the peer group [24].

5.19 Soil Corrosion and Integrity Management of Buried Pipeline

For a whole lot of reasons, the subject of soil corrosion skilled with the aid of using metal (steel) pipelines conveying petrochemical merchandise has come to be a challenge amongst operators, engineers and researchers. For over a century, soil corrosion has been acknowledged as one of the elements that make contributions to the failure of buried pipelines. In general, soil corrosion is an unfavourable mechanism because of the response with the surroundings that could degrade pipeline reliability and so reduces each its static and quality strength. Without a right tracking system, the dynamic development of corrosion can also additionally reason the pipeline to leak or rupture, and a pipeline failure can reason extreme human, environmental and economic losses. A lengthy and sustainable operation existence of buried pipelines is predicted as a result of the doubtlessly heavy economic losses if an ongoing operation needs to be suspended to permit for the restore and alternative of the brand-new section. Buried pipelines face erratic corrosion attack, despite the fact that upkeep is executed regularly, because of elements associated with soil conditions. These elements are in large part ruled with the aid of using uncertainties, and the trouble is those elements do now no longer have an effect on the pipeline similarly in any respect places as a result of the complicated phenomenon of soil behaviour. This is a connotation explaining that corrosion does now no longer develop on the identical charge all through a pipeline. Some elements of the path can be overprotected or below blanketed because the depth of the cathodic safety and coating existence are uniformly designed for outside safety. It is crucial for the operators to discover corrosion defects which can be lively or growing, most effective then can predictions of destiny corrosion severity for every and each disorder may be made. There is a large number of variables that affects corrosion in soil that's associated with physicochemical traits consisting of the position of microbes in soil corrosion, pH, temperature, moisture content, soil resistivity, redox capability, soluble ion content, oxidation-discount capability and chloride content (Cl-) in addition to the placement of the water table. Although previous studies targeted greater at the impact of physicochemical traits of soil upon corrosion dynamic, the impact of soil microstructure can't be neglected. The dynamics of corrosion can also additionally range in step with soil types. External steel loss because of corrosion as skilled with the aid of using buried pipelines may be monitored and detected through a whole lot of evaluation methods, along with In-Line Inspection (ILI) and the direct evaluation method. ILI gear consisting of mechanical pigging working primarily based totally on magnetic flux leakage (MFL) or ultrasonic (UT) standards are nicely designed to offer particular facts approximately the size, orientation and area of corrosion and different varieties of anomalies on a pipeline. It additionally offers facts concerning the regions at risk of eventual

failure. Areas with intense corrosion that could compromise pipeline integrity may be identified, assessed and eventually repaired. However, because the situation of a pipeline isn't a static state, corrosion that isn't at once addressed will keep growing and can be a risk to pipeline integrity. Projecting the increase of defects which will decide the probability of time to failure of operational pipelines isn't a honest task. Thisis because of inherent uncertainties related to soil residences, materials and imperfect dimension with the aid of using the inspection tool. Hence, the tracking of corrosion increase seems tobe much less powerful considering that no dependable prediction may be made because of the complexity of the corrosion mechanism. The want for a dependable empirical version mainly for the outside situation with the aid of using the operators intensifies. A dependable version be it empirical, theoretical or mechanical design is a great deal had to determine the closing existence of corroding pipelines on the time of inspection in addition to withinside the destiny. It also can be completely utilised to help the operators in designing a risk-primarily based totally upkeep programme, that's greater cost-powerful and much less conservative than the present-day exercise of time-primarily based totally upkeep program, (pre-set time c program language period of upkeep period) to steady the reliability of the road in opposition to corrosion attack [25].

5.20 Modelling and Optimization of Corrosion Penetration Rate (CPR) for Crude Oil Transportation Processes by Pipeline

Corrosion of carbon metal is a great trouble withinside the oil and fueloline manufacturing and additionally their transportation manner, which reasons great monetary loss. As a endresult of corrosion, rupture of the pipe wall often reasons failure of petroleum and fueloline pipelines.

The breakdowns are observed with the aid of using big losses of the products, environmental pollutants and ecological disasters. The majority of oil and fueloline pipelines screw ups end result from CO2 corrosion of carbon and occasional alloy steels. It happens in any respect degrees of manufacturing from downhole to floor gadget and processing facilities. The mechanism of carbon dioxide corrosion is a complex manner. This is stimulated with the aid of using many elements and situations temperature, pH, a partial strain of CO2, etc.[26] Oilfield corrosion manifests itself in numerous forms, amongst which CO2 corrosion (sweet corrosion) and hydrogen sulphide (H2S) corrosion (sour corrosion) withinside the produced fluids and corrosion with the aid of using dissolved carbon dioxide in water injection are the maximum normal types of assault discovered in oil and fuel line production. The Norsok -506 software program for corrosion measurements have been used as authentic values to introduce the skills of the expected novel evaluation methods. The prediction of CPR turned into achieved with methods, Response Surface Method (RSM) and fuzzy Logic (FL) approach, for the prediction and evaluation of the impact of a few decided on parameters, namely, temperature, pH, pressure, shear stress with the aid of using the ANOVA. The defuzzification manner in FL will pick with methods, the centroid and Root- Sum Square approach. Root- Sum Squareapproach will bring about the corrosion penetration charge with give an explanation for the motive of choice this approach. The evolved fuzzy good judgment version may even check with the aid of using evaluating the outcomes with the end result the usage of RSM technique. The assessment is made on the idea of the common absolute mistakes among the expected values and the real values. Based at the assessment among models advanced the use of fuzzy logic and RSM technique, it's far concluded that models primarily based totally on fuzzy logic exceed the suggest absolute blunders (MAE) of 0.0412 as opposed to 0.168 for RSM [26].

A) *Materials*

The pipe running material used on this is API grade X52 as follows, API refers back to the American Petroleum Institute, symbol X observed via way of means of a or 3-digit wide variety identical to the restrict of energy The exact minimal go with the drift in a thousand psi rounded to the closest complete wide variety, fifty-two, refers to a minimal pipe frame performance of 360 MPa (52,200 psi). The primary piping information is as follows: the period of the pipe is 513 km, the diameter of the pipe is (out of doors diameter) 34 in (864 mm) and the wall thickness is 9.5 mm, the kind of pipe is non-stop welding / spiral welding.[26] Mechanical homes are exact for a minimal yield energy of 358 MPa, an exact very last tensile energy of 455 MPa and a discipline carried out cuff coating. Chemical homes of the X52 pipeline with composition 0.16% C, 0.20% Cu and 0.45% Si, 1.10 - 1.60% Mn [26].

B) Development Of The Model

Fuzzy Logic (FL) primarily based on fuzzy set principle turned into mounted in 1965. In general, for any business manage application, the data wished for the preliminary evaluation and layout of the gadget is acquired divided into categories: virtual data and linguistic data acquired. These structures are then calibrated till the consequences start to produce responses in the direction of the unique goal. Simulations are run to validate the gadget and show its accurate overall performance for the precise problem. The styles of data, despite the fact that one-of-a-kind in nature, have not unusual place characteristics; every is commonly incomplete on its own. Although the gadget may be correctly managed with the aid of using an operator, a few data is misplaced while moving his experience to a professional gadget structure. On the alternative hand, beyond virtual information isn't always enough to expect destiny manipulate situations. The dim logic-primarily based totally research has observed packages in ambiguous and indecisive environments. In latest studies trends, multi-standards selection making strategies primarily based totally on fuzzy good judgment have emerge as very famous withinside the optimization of diverse production processes. Mamdani FIS as a result gives gadget designers greater flexibility in gadget layout. However, it must be referred to that the Mamdani FIS may be used without delay for MISO structures (single input, multiple output) in addition to for MIMO (multiple input multiple outputs) structures, even as Sugeno FIS simplest may be utilized in MISO structures. Fuzzy logic and linguistic variable standards have observed some of packages in fields as various as business method manage, medical diagnostics, credit score ratings, hazard evaluation, and greater. In the existing

look at of Mamdani, a fuzzy manipulate gadget is primarily based totally on fuzzy good judgment. , Mamdani kind may be summarized all of the steps proven in figure 14 [26].

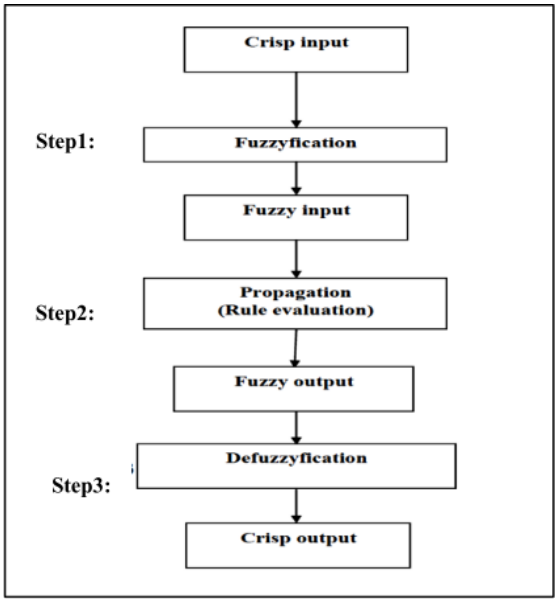

Figure 14 Steps of fuzzy control system [26]

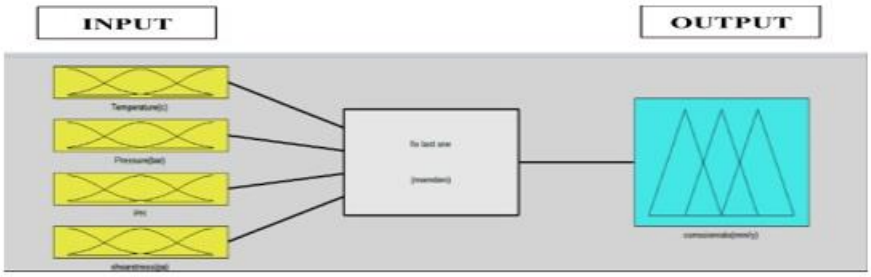

Figure 15 The four inputs-one output in "FIS Editor" [26]

A 4-input, one-output fuzzy logic system (CPR) is used. The inference engine (Mamdani fuzzy inference system) plays fuzzy inference with fuzzy policies to generate a fuzzy value. These fuzzy regulations are offered as "if-then" take a look at policies. Temperature, pH, strain, shear pressure are inputs to the fuzzy logic system. The language member capabilities for instance Low, Medium, and High are used to symbolize enter variables. Likewise, the output is represented via way of means of member capabilities along with Very low, low, medium, high, very high. The opacity of the 4 inputs, as an example temperature, pH, strain and shear pressure. A triangular club characteristic graph is exhibited to decide how the enter and output values (Y= CPR) are mapped to a value among zero and one. Linguist capabilities along with Low, Medium and High are used to symbolize input variables. Likewise, the output is represented via way of means of capabilities along with Very low, low, medium, high, very high [26].

Fuzzy Rules for Corrosion Penetration Rate of Composites API X52:
Rule1. If (temperature (C) is average) and (pressure (bar) is average) and (pH is average) and (shear stress (Pa) is average) then (corrosion penetration rate (mm/year) is low) (0.45)
Rule 2. If (temperature (C) is average) and (pressure (bar) is average) and (pH is average) and (applicable to) shear pressure (Pa) is medium) then (corrosion penetration rate (mm / a)) is low (0.45)
Rule 3. If (temperature (°C) is low) and (pressure (bar) high) and (low pH) and (shear stress (Pa) low) then (corrosion penetration rate (mm/a) is low V) (0.01)
Rule 29. If (temperature) (C) is average) and (pressure (bar) is average) and (pH is average) and (shear stress (Pa) is average) then (corrosion penetration rate (mm/ years) low) (0.45)
Rule 30. If (temperature (C) is average) and (pressure (bar) is average) and (pH is average) and (shear stress (Pa) is average) then (corrosion penetration rate (mm/a) is low) (0.45)
Rule 31. If (temperature (°C) low) and (pressure (bar) low) and (pH low) and (shear stress (Pa)) low) then (corrosion penetration rate (mm/y) is low V) (0.15)[26]

C) Simulation Of Logic Model Fuzzy

In this model, a fuzzy version became advanced primarily based totally on 31 experiments at the corrosion penetration charge of procedure parameters. The fuzzy modelling is simulated for the test instances which have been finished in the framework of the fuzzy set. Experiments have been executed for 3 stages of every parameter. The cause of simulation is to limit output mistakes for check case testing. In addition, to verify the completeness of the fuzzy logic version, the anticipated values of the anticipated corrosion rate the use of the proposed fuzzy version are in comparison to the anticipated values of the corrosion charge the use of RSM. This assessment is supplied in Table 2. The effects of the fuzzy logic simulation display that the anticipated values and the experimental values are in near settlement with every other. In a few instances, the anticipated values and the located experimental values are much less biased. This can be because of test blunders [26].

Table 2 The experimental, predicted and mean absolute error of the corrosion penetration rate [26]

Exp. No	*Predicted CPR, Using RSM ,(mm/y)*	*FL predicted result*	*Experimental CPR, Using (Norsok)*	*Error Using RSM*	*Error Using Fuzzy*
1	2.32	2.3	2.3	0.02	0
2	2.30	2.3	2.3	0	0
3	2.30	2.1	2.1	0.2	0
4	1.52	1.2	1.0	0.52	0.2
5	2.29	2.3	2.3	0.01	0
6	2.31	2.3	2.3	0.01	0
7	2.19	1.61	1.7	0.49	0.09
8	3.88	3.2	3.4	0.48	0.2
9	2.33	2.3	2.3	0.03	0
10	2.30	2.3	2.3	0	0
11	2.30	2.3	2.3	0	0
12	1.68	1.2	1.2	0.48	0
13	2.28	2.3	2.3	0.02	0
14	2.90	2.71	2.7	0.2	0.01
15	2.02	1.9	1.9	0.12	0
16	2.48	1.9	2.0	0.48	0.1
17	2.30	2.3	2.3	0	0
18	1.98	1.8	1.8	0.18	0
19	1.26	1.2	1.1	0.16	0.1
20	1.70	1.61	1.6	0.1	0.01
21	2.30	2.3	2.3	0	0
22	3.31	3.19	3.2	0.11	0.01
23	2.30	2.3	2.3	0	0
24	2.27	2.3	2.3	0.03	0
25	2.19	1.69	1.7	0.49	0.01
26	3.47	3	3.0	0.47	0
27	2.30	2.3	2.3	0	0
28	2.48	2.2	2.0	0.48	0.2
29	2.30	2.3	2.3	0.02	0
30	2.30	2.3	2.3	0	0
31	1.43	1.3	1.3	0.2	0
			MAE	**0.1814**	**0.0332**

D) Conclusion

During this approach, attempts have been made to expect the corrosion penetration rate of the pipelines used to move crude oil among the Tobruk and Sarir stations. Corrosion values have been measured by the use of well-known Norsok506 software program. The principle and concepts of corrosion have been additionally explained. The conclusions may be summarized as follows: 1. Based on ANOVA analysis, temperature, stress, pH and shear strain have a enormous impact at the corrosion charge, whilst the quadratic impact is negligible. However, the interaction among (temperature and shear stress), (stress and pH), (stress and shear strain) and (pH and shear strain) had a extra enormous impact at the corrosive penetration charge. 2. Based at the evaluation among models advanced the use of fuzzy logic and RSM method, its miles concluded that models primarily based on fuzzy logic are higher with a mean absolute blunder of 0.0412mm / a towards 0.1681 mm / a of RSM. 3. The finest values of CPR are calculated numerically through a fuzzy logic version with the use of the sum of squares, we discover that CPR = 2.16mm / year, temperature = 44.4 C, stress stress = 34, 28 Pa, pH = 5.54 and shear strain = 1bar. Research has demonstrated that there may be some other method which can provide consequences near actual facts in preference to Norsok software program which expenses hundreds of thousands of dollar [26].

5.21 Hydrogen Embrittlement (HE) in pipelines transporting sour hydrocarbons

Study of risk and damage mechanisms could be very essential to gain a very good integrity management. A lot of power has been executed withinside the beyond and continues to be underway toward a higher expertise of Hydrogen Embrittlement (HE) and its outcomes on load wearing metal (steel). Typically, engineers need to recognize if a material is at risk of cracking; moreover, early day selections or operational measures are frequently vital at some point of service life, to keep away from or retard this sort of risk or damage. HE is a everlasting lack of ductility in a metallic or alloy resulting from hydrogen in aggregate with pressure, both externally carried out or inner residual stress. However, the interplay of Hydrogen with metals under pressure could be very complex. Milling defects in pipeline metal mid-thickness (lamination-like defects) generally do now no longer propagate below operating situations in pipeline transporting hydrocarbons. In presence of moist H2S withinside the fluid, however, it's far feasible to take a look at blisters. From blisters, cracks might also additionally propagate withinside the metal. An estimate of crack increase rate for those defects may be beneficial to evaluate the integrity of pipelines and to set up suitable ILI intervals [27].

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CHAPTER SIX
CASE STUDY (DOW DEUTSCHLAND ANLAGENGESELLSCHAFT MBH (DOW) OHRENSEN, GERMANY AND REINHART HYDROCLEANING SA (RHC SA))

Before going over the numerous techniques for mechanical cleansing brine pipes, it is critical to be aware that RHC SA has been imparting cleansing answers for DOW pipelines from 2007. RHC SA cleans about ninety-one kilometres of DOWs pipeline community withinside the Ohrensen area. RHC SA keeps about ninety-one kilometers of pipes, ranging in period from 188 m to 27000 meter and consisting commonly of brine water pipelines (sixty two percent), mining water pipelines (33%), and sewage water pipelines (five percentage). Steel pipes account for over 60% of the overall period of the cited whole pipeline system, with polyethylene coated pipelines accounting for round 36% of the overall period. Cement-coated pipelines account for simplest 3% of all pipelines. To make sure a success ILI, the RHC MCTs are meant to deal with this venture and clean the pipeline in complete compliance with the operators specifications [28].

The RHC SA innovation is applied for 2 different packages with the aid of using DOW in Ohrensen. The first is to clean the brine solution H2O, mining water and sewage water pipelines to the vital norm to assure advent and powerful ILI. Assessment may be with Magnetic Flux Leakage (MFL) in metal (steel) pipelines and pipelines with polyethylene liner or Direct Magnetic Response (DMG) innovation in metal pipelines with installed liner. A consolidated mechanical cleaning/evaluation campaign is organized and achieved in most cases with a term of approximately one to one and half months for ten to fifteen pipelines, contingent upon length. This assure proceeded with pipeline execution and uprightness. Scale development is saved to a base level, diminishing exhaustion of the siphons, controls and contraptions even as augmenting advent flow making sure an powerful ILI at the subsequent organized sensible pig run [28].

The saline solution water pipeline is produced in the use of steel, predicted at 24" with an inward breadth of 596 mm and a whole duration of 19425 metre. This pipeline is wiped clean making use of RHC descaling gadgets on an regular base a couple of times (thrice) consistent with year. The sort of MCT used for this process is a pulling device with connected 180°pipeline surface insurance plough arm simple device with incorporated rotating detail pin pointing into the dimensions in addition to modules equipped with -layer scraping springsthat efficiently scrape off the dimensions and decreasing it to a powder [28].

Figure 16 Recycle MCT 24 Inch Front Graded Dust Scale [28]

The degree of scale eliminated from the pipeline with every run is confined via way of means of the degree of mechanical cleansing and the exciting coordinated detour this is coordinated to in shape the pipeline length and operating boundaries. A massive part of the powdered scale removed from the line divider is flushed ahead and stuck straightforwardly withinside the plant filtration model. During restoration one perceives that the dimensions is straightforwardly driven earlier than the cleansing equipment head. In principle, in light of estimation, approximately 3 - 3.5 mg of $CaCO_3$/l is left withinside the line at some stage in advent making the scale develop. The commonplace MCT scale evacuation cleansing runs 3 instances every yr indicates that the tough scale sections can be removed (regularly called "chips") are thicker than 0.5 mm [28].

Since executing everyday help cleansing of the pipeline in 2015 making use of the RHC SA Mechanical Cleaning Tools, the quantity and length of chips has diminished even as the degree of powdered scale increments asserting the managed and expulsion and the board of tough scale. This pipeline is analysed with a mining water pipeline with polyethylene liner, measured at 14 inch with an internal breadth of 346 mm and a entire period of 26620 metre. An adapted changed fundamental device head with seven ploughs geared up with rollers can be utilised for this operation. A rolling head and propulsion unit had been blanketed withinside the MCT's design. There aren't any sharp edges, and there are 3 propulsion discs in total, every with a changed pass primarily based on RHC SA's previous cleansing runs [28].

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The check in cleansing this pipeline is to perform maximum excessive viability in casting off present CaCO3 scale with 0 damage to the polyethylene liner. During plan and assembling of the mechanical cleansing instrument, beyond RHC experience and cleansing records changed into taken in consideration. Already before, to take out any risk of damage to the liner, the MCT turned into designed utilising wooden phase parts [28].

The equipment frame and internals have been produced using metallic with phase components that have been in direct touch with or may want to likely touch the line divider/liner have been produced the use of wood. RHC SA employs mechanical cleansing device from the primary run onwards, that is a giant alternate from normal pipeline cleansing procedures. Brush pigs do now no longer want the usage of several poly pigs (bare or coated), gauge plate pigs, or cup pigs. RHC SA starts cleansing on the primary run and improves cleansing overall performance via way of means of incorporating and combining diverse cleansing additives into the mechanical cleansing device. By limiting the quantity of pipeline pig release and get hold of trap operation, the whole quantity of cleansing runs is decreased whilst cleansing performance and overall performance are improved, decreasing now no longer simplest the charges in line with cleansing run however additionally the dangers of feasible exposure to human beings and the environment [28].

Figure 17 Shredded scale debris after the third MCT cleaning cycle in the 14-inch brine line [28]

Aside from descaling pipes from hard deposits like CaCO3, RHC SA's mechanical cleaning approach might be useful for pre-commissioning gas pipelines that transport things like oxygen, nitrogen, and hydrogen [28].

Concluding, the MCT layout changed into utilised two times to clean the stated pipeline. The cleansing records and pipeline manufacturing statistics have been considered to enhance the performance of this MCT. The problem changed into now no longer simply to layout a cleansing device that might now no longer damage the liner, however additionally to make it lighter with a bigger pass in order that it'd be greater powerful at getting rid of scale. Thisnew device configuration carried out so properly that it changed into determined to run it 3 instances every 12 months so as to maximise cleansing performance and manipulate scale elimination and build-up all through everyday operations. The MCT's massive quantity of scale plates created a putting visible effect. The quantity of powdered scale eliminated changed into nil due to the fact no scraping springs have been utilised, but the quantity of thick scale plates eliminated changed into impressive [28].

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CHAPTER SEVEN
CONCLUSION

A reliable, safe and environmentally responsible pipeline industry is vital to the nation. First, and immediately, a significant part of the country's energy supply depends on uninterrupted operation. In the long term, the offshore oil and gas industry as a whole could be seriously affected by major pollution incidents or fatal accidents due to pipeline failures. The safety record of the marine pipeline is good, but it needs to be improved, as society's willingness to take risks decreases. A pipeline integrity management program is needed for these pipeline systems to increase their reliability and availability, and to effectively manage and minimize maintenance, repair, and replacement costs over the long run. In this research we have covered many models regarding Pipeline integrity management programs (PIMS) and proposed frameworks furthermore, a detailed study on topics such Quality Control, Leak detection techniques and most important results learned from 20 years of challenges to internal corrosion protection of subsea pipelines corrosion inhibitor and Ph control, corrosion inhibitors nonetheless, a detailed case study on Dow Deutschland Anlagengesellschaft mbH (DOW) Ohrensen, Germany and Reinhart Hydrocleaning SA (RHC SA) was carried on and the results were studied and evaluated. A reliable, safe and environmentally responsible pipelineindustry is vital to the nation. A pipeline integrity management program is needed for these pipeline systems to increase their reliability and availability, and to effectively manage and minimize maintenance, repair, and replacement costs over the long run.

REFERENCES

All the following are **Journal articles**

[1]. F. Khan, R. Yarveisy, R. Abbassi, Risk-based pipeline integrity management: A road map for the resilient pipelines, J. Pipeline Sci. Eng. 1 (2021) 74–87. https://doi.org/10.1016/j.jpse.2021.02.001.
[2]. S.S. Gupta, A.K. Arya, P. Vijay, Implementation of Pipeline Integrity Management in a Large Pipelines Network in India, Int. J. Recent Technol. Eng. 8 (2019) 3019–3027. https://doi.org/10.35940/ijrte.d7597.118419.
[3]. M. Hussain, A. Hussain, An overview of energy pipeline integrity management, and future asset management strategies Condition based maintenance and operation of wind turbines View project Energy Pipeline Integrity Management System View project, n.d. https://www.researchgate.net/publication/344725257.
[4]. M.A. Usman, S.E. Ngene, An innovative approach to managing the integrity of oil and gas pipelines: Pipeline integrity management system, Pet. Coal. 54 (2012) 1–8.
[5]. M. Nazmi, M.A. Napiah, M. Hisham, A. Bakar, A. Sirwan, M. Tuselim, IPC2020- 9321 PIPELINE INTEGRITY MANAGEMENT AND THE INVENT OF ANALYTICS, n.d.
[6]. LeisDataIntegrationPaper (1), (n.d.).
[7]. M. Xie, Z. Tian, A review on pipeline integrity management utilizing in-lineinspection data, Eng. Fail. Anal. 92 (2018) 222–239. https://doi.org/10.1016/j.engfailanal.2018.05.010.
[8]. P.L. Dus, A.C.R. Valente, A. Valdes, Pipeline integrity management in an urban environment supported by an external corrosion direct assessment (ECDA) application, Rio Pipeline Conf. Expo. Tech. Pap. 2009-Septe (2009) 1–7.
[9]. Z. Barrett, J. Wiese, M. Israni, P. Wood, IPC2004-540 Office of Pipeline Safety, (2016) 1–5.
[10]. H. Iqbal, B. Waheed, H. Haider, S. Tesfamariam, R. Sadiq, Mapping safety culture attributes with integrity management program to achieve assessment goals: A framework for oil and gas pipelines industry, J. Safety Res. 68 (2019) 59–69. https://doi.org/10.1016/j.jsr.2018.12.010.
[11]. E.I. for I. and T.T. GmbH, Pipeline Technology Journal, Pipeline Technol. J. 2 (2020).
[12]. P.T. Conference, For all those thinking big ., (n.d.).
[13]. S. Issue, Pipeline Technology Journal Special Issue: Pipeline Safety in Germany, (n.d.).
[14]. K. El-Akruti, T. Zhang, R. Dwight, Maintaining pipeline integrity through holistic asset Management, Eur. J. Ind. Eng. 10 (2016) 618–638. https://doi.org/10.1504/EJIE.2016.078805.
[15]. J. Tejedor, J. Macias-Guarasa, H.F. Martins, S. Martin-Lopez, M. Gonzalez-Herraez, A multi-position approach in a smart fiber-optic surveillance system for pipeline integrity threat detection, Electron. 10 (2021) 1–19. https://doi.org/10.3390/electronics10060712.
[16]. M. Samnejad, M. Aboelatta, C. Vu, D. Wood, Asset Inspection Powered by Computer Vision: The Use of Deep Neural Networks for Automating the Detection and Classification of Pipeline External Damage, 2021.
[17]. N.M. Noor, N. Apaziah, N. Ozman, N. Yahaya, M.N. Mohd, A. Napiah, Z. Abdullah, PICA: PIPELINE INTEGRATED CORROSION ASSESSMENT TOOL FOR STRUCTURE INTEGRITY, n.d.
[18]. G. Giunta, S. BUDANO Centro Sviluppo Materiali SpA, A. Lucci, PVP2012-78545 PIPELINE HEALTH INTEGRITY MONITORING (PHIM) BASED ON ACOUSTIC EMISSION TECHNIQUE, n.d.
[19]. W. Chalgham, K.Y. Wu, A. Mosleh, System-level prognosis and health monitoring modeling framework and software implementation for gas pipeline system integrity management, J. Nat. Gas Sci. Eng. 84 (2020) 103671. https://doi.org/10.1016/j.jngse.2020.103671.
[20]. R. Heidary, K.M. Groth, A hybrid model of internal pitting corrosion degradation under changing operational conditions for pipeline integrity management, Struct. Heal. Monit. 19 (2020) 1075–1091. https://doi.org/10.1177/1475921719877656.
[21]. S. Jiang, The application of internet of things technology in integrity management of urban gas pipe network, IOP Conf. Ser. Earth Environ. Sci. 632 (2021). https://doi.org/10.1088/1755-1315/632/5/052016.
[22]. M.I. Mohd Ismail, R.A. Dziyauddin, N.A.A. Salleh, F. Muhammad-Sukki, N.A. Bani,
[23]. M.A.M. Izhar, L.A. Latiff, A review of vibration detection methods using accelerometer sensors for water pipeline leakage, IEEE Access. 7 (2019) 51965– 51981. https://doi.org/10.1109/ACCESS.2019.2896302.
[24]. P. Monti, C. Molinari Saipem Energy Services SpA Sealines, S. Division San Donato Milanese, I. Massimiliano Bocciarelli, A. Corigliano, S. Mariani, OMAE2011-49178 STRUCTURAL INTEGRITY ASSESSMENT OF A PIPELINE SUBJECTED TO AN UNDERWATER EXPLOSION, 2011.
[25]. H. Iqbal, B. Waheed, S. Tesfamariam, R. Sadiq, IMPAKT: Oil and Gas Pipeline Integrity Management Program Assessment, J. Pipeline Syst. Eng. Pract. 9 (2018) 06018003. https://doi.org/10.1061/(asce)ps.1949-1204.0000326.
[26]. S. Rabeah Othman, Soil Corrosion and Integrity Management of Buried Pipeline, 2012. https://www.researchgate.net/publication/270584595.
[27]. R.A. Elrifai, Modelling and Optimization of Corrosion Penetration Rate (CPR) for Crude Oil Transportation Processes by Pipeline, Int. J. Sci. Eng. Appl. 7 (2018) 324– 330. https://doi.org/10.7753/ijsea0709.1015.
[28]. G. Gabetta, F. Pagliari, N. Rezgui, Hydrogen Embrittlement in pipelines transporting sour hydrocarbons, Procedia Struct. Integr. 13 (2018) 746–752. https://doi.org/10.1016/j.prostr.2018.12.124.
[29]. Ptj, Pipeline Technology Journal - Industry, Digitalizationthe Pipeline, (2019).