Integrity Management in Cross-County pipelines

J. P. SINHA
PL HO NOIDA

INDIANOIL CORPORATION LIMITED
(PIPELINES DIVISION)
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Pipeline network length of approx 11200km and growing

Diameters from 8” to 48”

Capacity of approx. 80 MMTPA

80 installations across India

5 Single Point Mooring systems

68 bulk crude storage tanks (approx. capacity 4.5 Million KL)
Pipeline systems are the safest and the most environment friendly mode of transportation of crude petroleum, refined products and natural gas.

- Being a closed system, minimal handling and transit losses as compared to other means of transportation, hence most efficient.

- Safety & Reliability – minimum disruptions.
Petroleum pipelines carry hazardous products

The impact of pipeline failure on the environment and society cannot be overlooked

It is essential to adopt a pro-active approach in management of hazards so as to:

- Eliminate/minimize harm to people and environment,
- Damage to property, and loss to the pipeline companies.
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Consequences of failure

- Failure/loss of containment
  - Fire/explosion
  - Loss of life/serious injuries
  - Environmental damage (land/waterways)
  - Pollution and health hazards
  - Losses – profit/productivity
  - Liabilities
  - Penalties
Major challenges in Operation & Maintenance of pipelines

- Pilferage/Third party activities.
- Encroachments/urbanisations
- Natural Calamities/Washout/snapping of pipelines.
- Attending pipeline leak/Failure in unfavorable location or gradient.
- Failure of Low frequency ERW mainline pipes.
Major challenges in Operation & Maintenance of pipelines

- Common ROW.
- Interference due external source/CPs
- Rehabilitation of CTE (over the ditch) coated pipelines.
- Internal corrosion.
Asset Integrity starts from the design stage i.e. good design followed by sound construction, safe operation and effective maintenance.

Pipelines to be regularly monitored for all relevant threats, maintained & remediated to achieve safe operation throughout its design life, and

Pipeline life can be extended much beyond the design life until economically unviable.
Design & Engineering Phase

- Selection of pipeline route
- Material selection for main line pipe and pipe fittings
- Design & lay out of station, mainline & HDD crossings
- Selection of proper coating system
- Designing an effective CP system
- Ensuring appropriate Safety factors during design
- Risk assessment and incorporating mitigation measures
- Environmental Impact Assessment
Pipeline route is carefully selected to stay clear of inhabited areas to the maximum extent possible.

Pipeline route is selected to avoid reserved & protected forest area, wild life sanctuaries, water logged and marshy areas etc. to the maximum extent possible.

Satellite Imagery and Geographical Information Systems (GIS) are used for route selection and finalization.
Construction Phase

- Proper Inspection
- Adherence to approved specifications and procedures
- Monitoring Workmanship
- Hydrostatic test
- Records for future reference
High Grade Steel Pipes (conforming to International Code API 5L) are used for constructing cross country Pipelines.

The typical sizes of the Pipes are as under:
- Diameter - 4 inch – 56 inch
- Pipe thickness - 0.219 inch – 1 inch

Pipes are welded and inspected as per the most stringent international standards.
Transportation of Pre-coated Pipes to Site

String of Pipes in ROW
Pipeline Construction

Welding of Pipes in Progress

Joint after Welding
Pipeline Construction

Lowering of the Pipeline
Operation & Maintenance Phase

- Line Patrolling/ROW Inspection
- Inspection of Mainline Facilities /Xings.
- Online Monitoring of Pipeline Parameters through Supervisory Control and Data Acquisition System (SCADA)
- Leak detection systems (LDS) are provided to detect any abnormal change in pressure and flow parameters and to also locate the location of such incidence.
Integrity Management Practices in Indian Oil

Thrust Areas

- Monitoring Pipeline Integrity
- Monitoring Cathodic Protection
- Monitoring Coating
External Corrosion Protection In Mainline

- Protective coatings
  - the first line of defence
- Cathodic Protection
  - used as a supportive technique
To safeguard against external corrosion, pipes are coated from the following type of materials:

- 3LPE - Three Layer Polyethylene
- 3LPP - Three Layer Polypropylene
- DFBE - Dual Layer Fusion Bonded Epoxy
- Coal Tar Enamel

In addition to the anti-corrosion coating, the pipelines are also provided with custom designed Cathodic Protection systems.
Internal Corrosion Management

MITIGATION STRATEGIES

**Pigging**
- Pig Type selection
- Pigging Frequency
- Use of Pig Trains

**Chemical Treatment**
- Film Forming Inhibitors
- Oxygen Scavengers
- Biocides

**Operational Aspects**
- Product / Crude quality
- Separator Filters
- Settling Time
- Water draining
Internal Corrosion Management

MONITORING

- Pig/Strainer residue analysis
- Weight Loss Coupons
- Electrical Resistance (ER) Probes
- UT probes
External Corrosion Management

- Coatings health periodically assessed through
  - CAT Surveys
  - DCVG Surveys

- Cathodic Protection effectiveness assessed through
  - Routine PSP and Current measurements
  - Periodic Close Interval Potential Surveys (CIPS)

- Corrective actions
  - CP TRU unit repair/replacement
  - Anode bed renovation
  - Repair of damaged coating
INLINE INSPECTION TOOLS & TECHNOLOGIES

- **Magnetic flux leakage (MFL)**
  - High and low resolution axial
  - Circumferential or transverse flux inspection

- **Ultrasonics**
  - Normal beam (wall thickness)
  - Angle beam (cracks)

- **Electromagnetic acoustic transducer (EMAT)**

- **Geometry**
  - Caliper (low resolution)
  - Deformation (High resolution)

- **Acoustics for leak detection**
  - Spheres or Mandrel Pigs fitted with acoustic sensors
Introduction of Intelligent Pig Survey (IPS)

IPS is a well proven and latest technique for health monitoring of a pipeline and it can scan the complete pipeline.

Generally following two types of IPS tool are used :-

1) Ultrasonic Type

2) Magnetic Flux Leakage (MFL)
   a) Longitudinal
   b) Transverse
   c) Spiral
Ultrasonics based IPS
View of 30” UT Tool during pre-launch testing
GENERAL VIEW OF MFL IPS TOOL
Magnetic Flux Leakage based IPS
HiRes Axial Flaw Detection Tool (AFD)
The character, amplitude and various other measurements are used to determine the depth, length and width of the recorded metal loss.
Axial MFL technology detects volumetric pipeline anomalies, general corrosion and wide circumferential flaws.

TFI tools are designed to detect general corrosion, as well as long and narrow metal loss features.

Spiral MFL tool, which is a combination of MFL and transverse field inspection, can detect long, narrow defects in a pipe body and in long seam welds.
Spiral MFL IPS Tool
Smart Ball Leak Detection Tool

- M/s Pure Technologies, Canada conducted trial of their acoustic sensor based Smart Ball leak detection tool in one of our pipelines.
Crack Orientation & Measurement Principles at a Glance

- a) Detection of axial defects
- b) Detection of defects in the spiral weld
- c) Detection of circumferential defects
CASE STUDIES
Third Party Damage-Pilferage attempts
पाइप लाइन से तेल चोरी
आईओसी की पाइप लाइन से की चोरी, पांच टैंकर जब्त, छह जने पकड़े गए
PILFERAGE ATTEMPTS

TANKER CAUGHT BY POLICE AT SITE
Pipeline failure in heightened security area
Pipeline failure in heightened security threat area

- Site was located in a remote area and declared as highly disturbed from internal security standpoint.
- Very difficult to approach due to adverse terrain and absence of motorable approach.
Leak in crude oil pipeline

A View of Damaged Pipe
Around 300 armed paramilitary personnel were deployed at site.

Deployed at site round the clock
Third Party Damage & Detection by IPS
The pipe was exposed at the location and a 4” long crack was observed at 9 o’clock location.

The leak was arrested by fitting a mechanical bolt-on leak clamp over the crack.
First time such High Resolution UT Technology (Ump) was used for IPS of Pipelines in the country.

**Salient Features of the UT Tool:**

1. Direct Measurement of Thickness.
2. No. of UT Transducers: $19 \times 32 = 608$
3. Axial Resolution: $1.5 \text{mm}$
4. Circumferential Resolution: $3.7 \sim 4.0 \text{mm}$

Tool would acquire over 1.66 Lakh thickness measurements every 1 sq.m.

i.e. tool would acquire over 4 Lakh UT thickness measurements for each metre of pipe scanned!
View of UT tool before Launch

View of UT Tool during pre-launch testing
Damage to Pipeline due to River erosion
RIVER IN ITS FULL FURY
EFFORTS ARE ON FOR DIVERSION OF RIVER FLOW
A VIEW OF DAMAGED PIPE ENDS.
To sum up, Preparation & Implementation of Integrity Management Plan for all pipelines is an extremely important and challenging task for the Pipeline operators.

- All Oil company need to be at the forefront in adopting new technologies and strategies to control and mitigate the risks involved with pipelines.

- Pipeline operators also require the support of the local public and administration in combating the menace of pilferage.