GAIL (India) Limited

LPG PIPELINE REPAIR TECHNIQUES

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MODULES COVERED IN THE TRAINING

- **LPG Basic Information**
- **Pipeline Benefits**
- **Pipeline Disadvantages**
- **Classification of the defect**
- **Pipeline Repair Techniques**
  - Cut out and replace
  - Dress out and grinding / In-situ welding
  - Fillet welded patch
  - Mechanical clamps
  - Full encirclement sleeve
  - Composite overwrap
  - Hot Tapping

LPG BASIC INFORMATION

Definition

The term LPG applies to a mixture of certain light hydrocarbons derived from Petroleum which are gaseous at normal ambient temperature and atmospheric pressure but may be condensed to the liquid state at normal ambient temperature by the application of moderate pressure (IS 4576).

- In India, LPG is predominantly a Mixture of propane (C_3H_8) and butane (C_4H_{10}).
- Propane and Butane are both colorless and odorless in both gas and liquid phases. Operators add odorant so that it can be detected.
- At normal ambient temperature and pressure LPG is a gas.
- Under pressure it is a liquid and hence extremely useful as a fuel for storage and transportation in bottles.
- The composition of Propane to Butane in LPG varies depending upon the country and the temperature.

LPG BASIC INFORMATION

- Density of commercial liquid LPG (butane – propane mixture) : 0.5 - 0.6 Kg/L.
- Liquid LPG is lighter than water. Gaseous LPG is about 50% heavier than air.
- It forms crystalline ice type hydrates when mixed with water at certain pressure and temperature.
- **Extremely dangerous : can be very destructive as it can accumulate in low areas, and if ignited can result in vapor cloud explosions.**
- Non-toxic but highly explosive.
- Odourisation is not always effective.
- Rapid temperature cooling when LPG goes from liquid to gas.

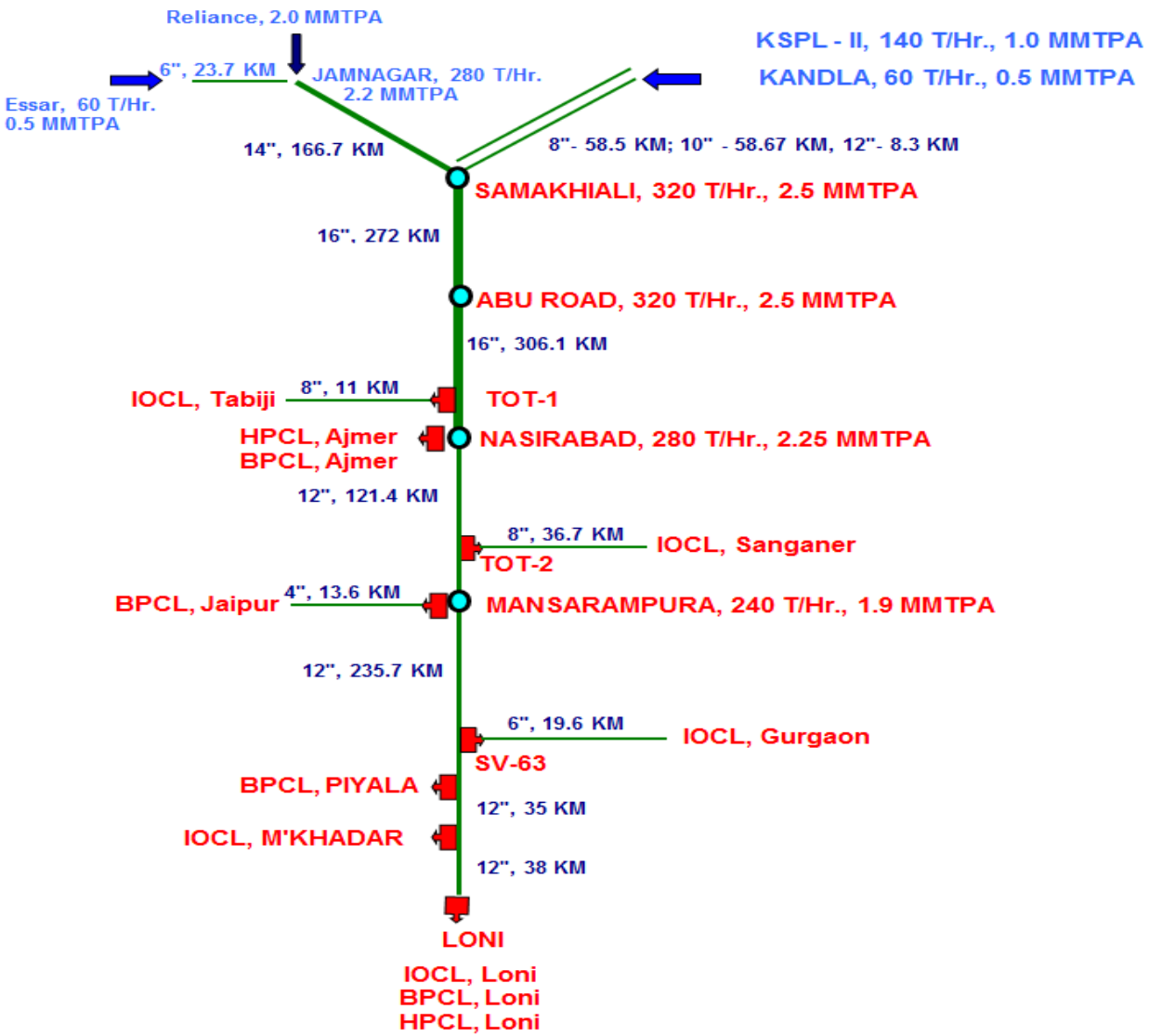
LPG PIPELINE BENEFITS

- Carry large volumes of LPG through long distance.
- Generally low maintenance.
- Cost advantages over other means of transport i.e. road and rail.
- Low operating costs.
- Relatively safe method of transport **provided operated and maintained correctly.**
- Long operating life **provided maintained correctly.**

LPG PIPELINE DISADVANTAGES

- High initial capital cost.
- Carry high pressure flammable and explosive fluid (LPG) with associated inherent dangers.
- Subject to third party damage.
- Catastrophic effect in the event of pipeline failure (leak / burst).
- Very high impact on the public and third parties in the event of failure.
- Short operating life if not operated and maintained correctly.
- Safe evacuation of large volume of LPG from the pipeline in case of leak / burst etc. is very difficult.

JLPL – PIPELINE OVERVIEW



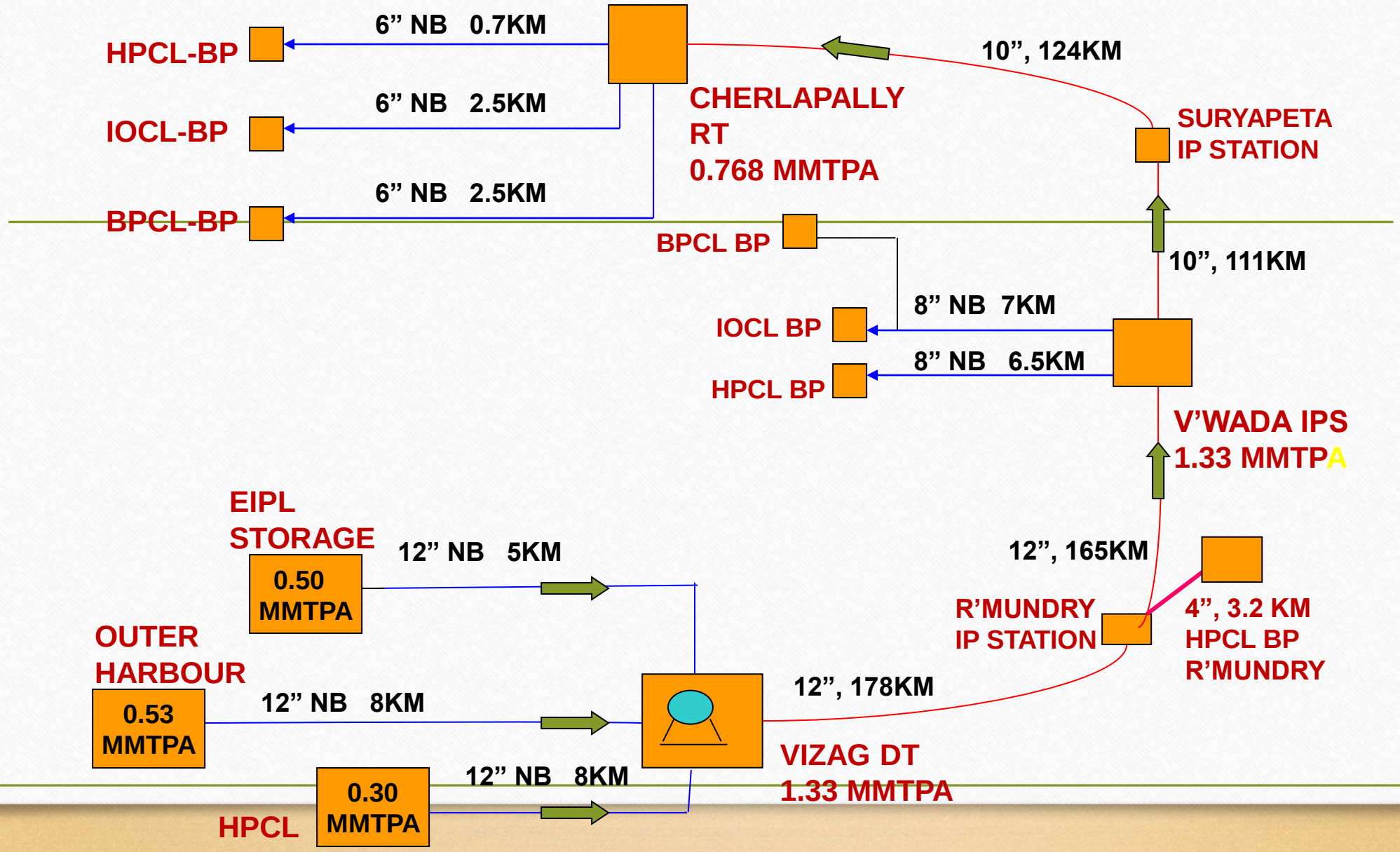
Length Break Up

16"	578.1 KM
14"	166.7 KM
12"	439.0 KM
10"	58.67 KM
8"	114.3 KM
6"	43.3 KM
4"	13.6 KM
TOTAL	1414 KM

LEGEND

- Despatch Stations - 3 Nos
- Tap -Off Points - 11 Nos
- Booster Stations - 4 Nos.

VSPL – PIPELINE OVERVIEW



CLASSIFICATION OF THE DEFECTS

Following are the broad classification of the pipeline defects :

- Dents – indentations of the pipe caused by external forces.
- Mechanical damage – injurious damage to pipe surface caused by external forces, e.g. gouges, grooves, scrapes, external corrosion, arc burns etc.
- Welds imperfections and manufacturing defects
- Non-leaking internal / external corrosion related defects.
- Cracks and Pin hole leaks due to AC/DC interference.

PIPELINE REPAIR CRITERIA

All anomalies (defects) discovered during integrity assessment / inspection such as intelligent pigging, bell-hole inspection, DCVG, CIPS etc. or reported otherwise shall be evaluated and classified under the following three categories based on severity of defect (Ref. Maintenance Policy and Guidelines) :

a) **Immediate repair condition** – Indication shows that defect is at failure point. In case of Immediate repair condition, the operating pressure shall be immediately lowered to 80% of pressure at which pipeline was being operated or the affected section shall be isolated as the situation demands. The defect location shall be treated as "Vulnerable Location" and monitored accordingly, till permanent repair action is taken.

b) **Scheduled Repair condition** – Indication shows that defect is significant but not at failure point.

c) **Monitored conditions** – Indication shows that defect will not fail before next scheduled inspection.

IMMEDIATE REPAIR CONDITIONS

Following indications qualifies for immediate repair conditions :

- Pipeline failure (Leak & Rupture)
- A dent with depth exceeding 2% of nominal pipeline diameter on girth and seam welds or ***dent of any depth with cracks***.
- A plain dent with depth that exceeds 6% of nominal pipeline diameter.
- Metal loss with pipe wall thickness reduction - 70% or above.
- ERF = 1 or above (ERF = MAOP/SOP calculated as per ASME 31G)
- Any indication of adverse impact on the pipeline expected to cause immediate or near term leaks or ruptures based on their known/perceived effects on the strength of pipeline which include dents with gouges, welding defects etc.
- ***In case of LPG pipeline,*** a dent located on top of the pipeline (above the 4 and 8 o'clock positions) with a depth greater than 2% of pipeline diameter (greater than 0.25" in depth for a pipeline diameter less than nominal pipe size of 12").
- ***In case of LPG pipeline,*** any dent that contains indications of stress risers (e.g. gouges, grooves, scratches) or corrosion.

SCHEDULED REPAIR CONDITIONS

Following indications qualifies for scheduled repair conditions :

- Pipe wall thickness reduction - 40% to 70%.
- ERF >= 0.95 but less than 1.

- The defect location confirmed as scheduled repair conditions shall be declared as "Vulnerable Location" and monitored accordingly, till permanent repair action is taken.
- Detailed assessment of above anomalies shall be performed to find out the remaining life of the pipeline containing time dependent defects.
- Repair action shall be taken before its calculated remaining life or within two years from the date of discovery, whichever is earlier.

MONITORED CONDITIONS

Following qualifies for monitored conditions :

- Metal Loss anomalies with depth up to 40% and having ERF less than 0.95
- Geometric anomalies which are not covered in immediate and scheduled category.
- Monitored indications are least severe and typically will not require examination and evaluation until the next scheduled integrity assessment stipulated by the integrity management plan, *provided that they are not expected to grow to critical dimensions prior to the next scheduled assessment.*
- Detailed assessment of time dependent anomalies shall be performed to find out the remaining life of the pipeline and action shall be planned before its calculated remaining life for repair or re-inspection.

PIPELINE REPAIR METHODOLOGY

- A schedule for repair shall be prepared for all defects to be attended / monitored and mitigation action shall be undertaken accordingly, in a time-bound manner to eliminate an unsafe condition detrimental to the integrity of the pipeline.
- *Recommendations of external consultant / Integrity experts may be obtained for suitable repair action, if required.*
- Permanent measures for repair shall be completed *at least one year prior to the recommended date / year as per the FFS / RRR report on ILI.*
- If temporary repair measures such as installation of leak repair clamp (bolt-on clamps) is required to be employed immediately to protect the property and public, same shall be converted / changed into permanent repair *at the earliest available opportunity or within six months whichever is earlier.*
- Root cause analysis shall be carried out and action may be initiated to arrest the root cause of the defects.

DERATING OF THE PIPELINE WITHOUT REPAIR

There is an option to decrease the Maximum Allowable Operating Pressure (MAOP) of the pipeline if the defect will cause pipeline failure at current operating pressure, and if defect is too difficult or extensive as well as expensive to repair, e.g. :

- Corrosion along the length of a seam weld in a pipeline.
- When there are clusters of internal defects over a long distance of the pipeline.

PIPELINE REPAIR TECHNIQUES

Following are the various repair techniques normally adopted, based on the type of the defect :

- Cut out and replace, (P/L Shut down feasible cases)
- Dress out and grinding / In-situ welding.
- Fillet welded patch.
- Mechanical clamps.
- Full encirclement split sleeve weld repair
- Composite overwrap / Clock Spring.
- Hot Tapping & P/L Stopping Method

CUT OUT AND REPLACE

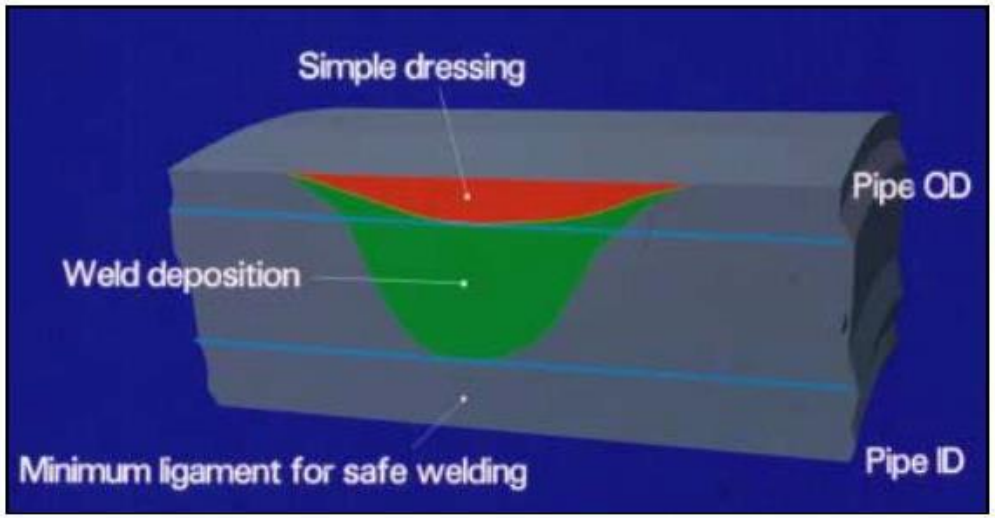
- Replacement of defective pipeline section ***is the best available option*** to repair the non-acceptable defects permanently. In case the pipeline is under shutdown or where shutdown is feasible then the defects shall preferably be repaired ***by replacement method only.***
- The section containing non-acceptable defects shall be cut out as cylinder and replaced after shutdown, depressurization and isolation of the process fluid from defective area.
- The length of the section removed / replaced should be a minimum of 1.5 D or 300 mm whichever is longer. The replacement pipe section shall have strength of at least that of the pipe it replaces and comply with original pipe specification.
- As per GAIL's maintenance guidelines, if any one pipe length having more than 2 defects of Immediate or Scheduled category at an interval of less than 1.5 M or cluster of defects with metal loss more than 20% and at least one of them is of immediate or scheduled category, then the repair shall be done by replacement of full pipe length.

DRESS OUT AND GRINDING

- Grinding is the removal of defect by hand filing or power disc grinding.
- For base metal or welds containing fabrication or service induced defects such as weld flaws, arc burns, gouges, corrosion, and minor metal cracks may be repaired by grinding out the damage, ***provided any associated indentation of the pipe does not exceed a depth of 4% of the nominal pipe diameter.***
- Grinding is permitted to a depth of 10% of the nominal pipe wall thickness with no limit on length.
- Grinding is permitted up to a maximum of 20% of the pipe wall thickness, provided that the length of the ground area is no more than that allowed by ASME B31G code.
- The areas of grinding shall always be verified for the presence of cracks by NDT crack detection techniques (e.g. MPI / UT shear wave etc.). If cracks are observed, the same shall be removed by grinding subject to the maximum wall thickness allowed for grinding as above.
- The ground surface is to be re-examined by MPI to confirm that the defect / crack has been completely removed.

DRESS OUT AND GRINDING

IN-SITU WELDING



Cavity is ground smooth with sides / edges beveled for weld deposition, weld material is deposited in the cavity (sometimes root pass is examined with LPI), completed weld is smoothed and polished, and area is inspected by UT / RT.

DRESS OUT AND GRINDING

- Recommended to shut-down line before grinding, but if performed in service, system pressure should be reduced to 80% or less to reduce risk of rupture / leak during grinding.
- During welding / weld deposition, precaution to be taken to avoid burn-though, excessive residual stresses, hydrogen cracking and reduced toughness of the weld repair area. Flow of fluid in pipe tends to cool weld more rapidly, hence flow has to be regulated.
- Remaining smooth depression must remain above the minimum wall thickness required by code, otherwise conditions required to be analyzed for fitness for service.
- Although the technique is recommended as per ASME B 31.8, Section 851.42, *for LPG pipelines the technique is to be applied with extreme caution.* A procedure needs to be developed and followed to prevent localized heating of the LPG causing gas formation.

DRESS OUT AND GRINDING

ASME B31.8, Section 851.42

(3) External mechanical damage, including cracks, may be repaired by grinding out the damage provided any associated indentation of the pipe does not exceed a depth of 4% of the nominal pipe diameter. Grinding is permitted to a depth of 10% of the nominal pipe wall with no limit on length. Grinding is permitted to a depth greater than 10% up to a maximum of 40% of the pipe wall, with metal removal confined to a length given by the following equation:

$$L = 1.12\left[(Dt)\left(\left(\frac{a/t}{1.1a/t - 0.11}\right)^2\right) - 1\right]^{1/2}$$

where

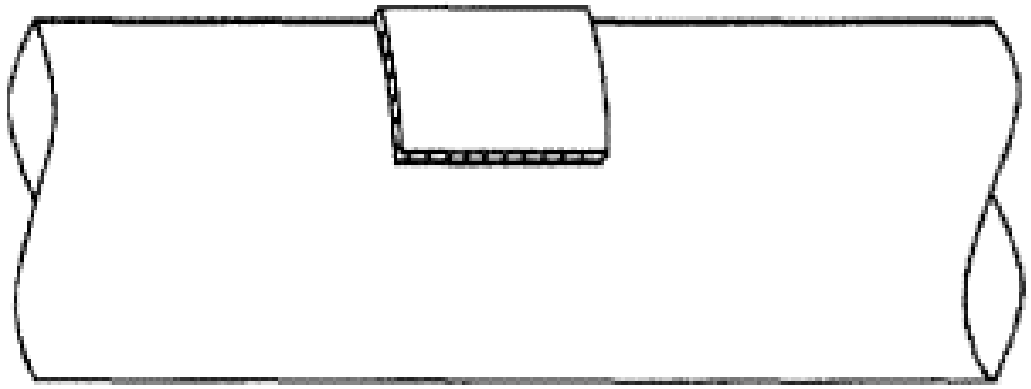
D = nominal outside diameter of the pipe, in.
L = maximum allowable longitudinal extent of the ground area, in.
a = measured maximum depth of ground area, in.
t = nominal wall thickness of pipe, in.

FILLET WELD PATCH

- Simple to install - involves fillet welding circular or square patch with rounded corners along outside length of pipe.
- Patch must be similar or higher grade material than pipe, and thickness comparable to pipe.

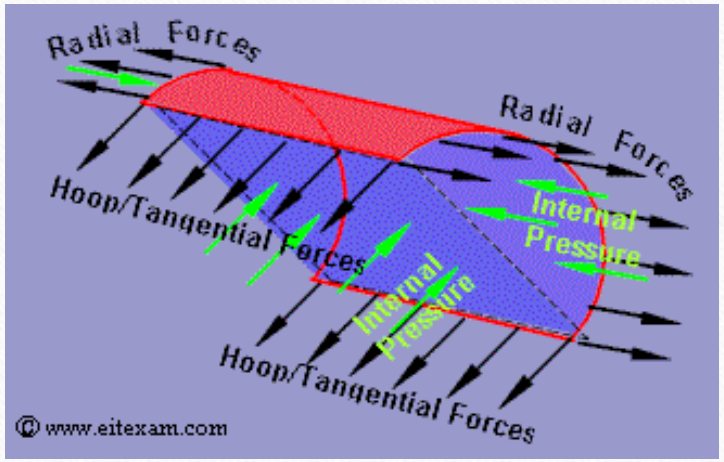
ASME B31.8, Section 851.44

(e) Leaking or nonleaking corroded areas on pipe of not more than 40,000 psi specified minimum yield strength may be repaired by using a steel plate patch with rounded corners and with dimensions not in excess of one-half the circumference of the pipe fillet welded over the pitted area. The design strength of the plate shall be the same or greater than the pipe.

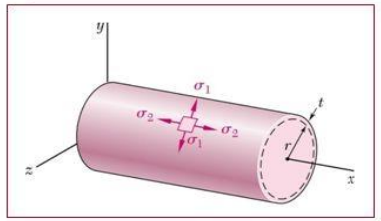


FILLET WELD PATCH

Commonly used in liquid HC pipeline except for pipelines *where hoop stress exceeds 20% of yield stress.*



Cylindrical Pressure Vessel

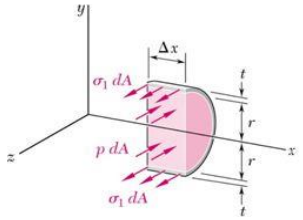


Circumferential (Hoop) Stress: σ_1

Sum forces in the vertical direction.

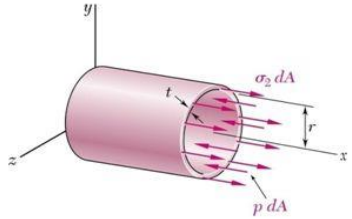
$$2\sigma_1(t\Delta x) - p(2r\Delta x) = 0$$

$$\sigma_1 = \frac{pr}{t}$$



Longitudinal stress: σ_2

Sum forces in the horizontal direction:



$$\sigma_2(2\pi rt) - p(\pi r^2) = 0$$

$$\sigma_2 = \frac{pr}{2t}$$

Thin-Walled Pressure Vessels 24

FILLET WELD PATCH

Although recommended as per ASME B 31.8, Section 851.44, the fillet weld patch has the following potential source of problems and hence *may not be applied in LPG pipeline :*

- Fillet welds in longitudinal direction faces twice the stress of the circumferential direction, and
- Fillet welds have poor fatigue properties and are difficult to inspect thoroughly.

MECHANICAL CLAMPS

- For temporary / short-term repair of pin hole/leaks mechanical clamp can be used. Bolt-on clamps are designed to contain full pressure. They are generally bulky and heavy to ensure an adequate clamping force.
- Temporary clamp should be removed within 90 days of installation.
- May be installed online – system pressure to be reduced to safe operating pressure or 80% of current operating pressures whichever is less till the completion of repair.
- Comprised of two flanged heavy wall split shells and elastomeric seals which engage on parent pipe OD during bolt-up. Installed on damaged or leaking pipework, encapsulating the defect within the clamp body and maintaining pressure containment.
- Thermosetting sealant may be injected between leaking pipe and clamp – cured sealant seals the leak.
- Circumferential and axial welding of the clamp may be completed at the earliest available opportunity or within three months whichever is earlier (as per ASME B 31.8) to convert it to permanent repair. As per GAIL's Maintenance guidelines also, no further action is required for permanent measure in this case.

MECHANICAL CLAMPS

MECHANICAL CLAMPS

CUSTOMISED MECHANICAL CLAMP USED IN VSPL CH. 485 KM

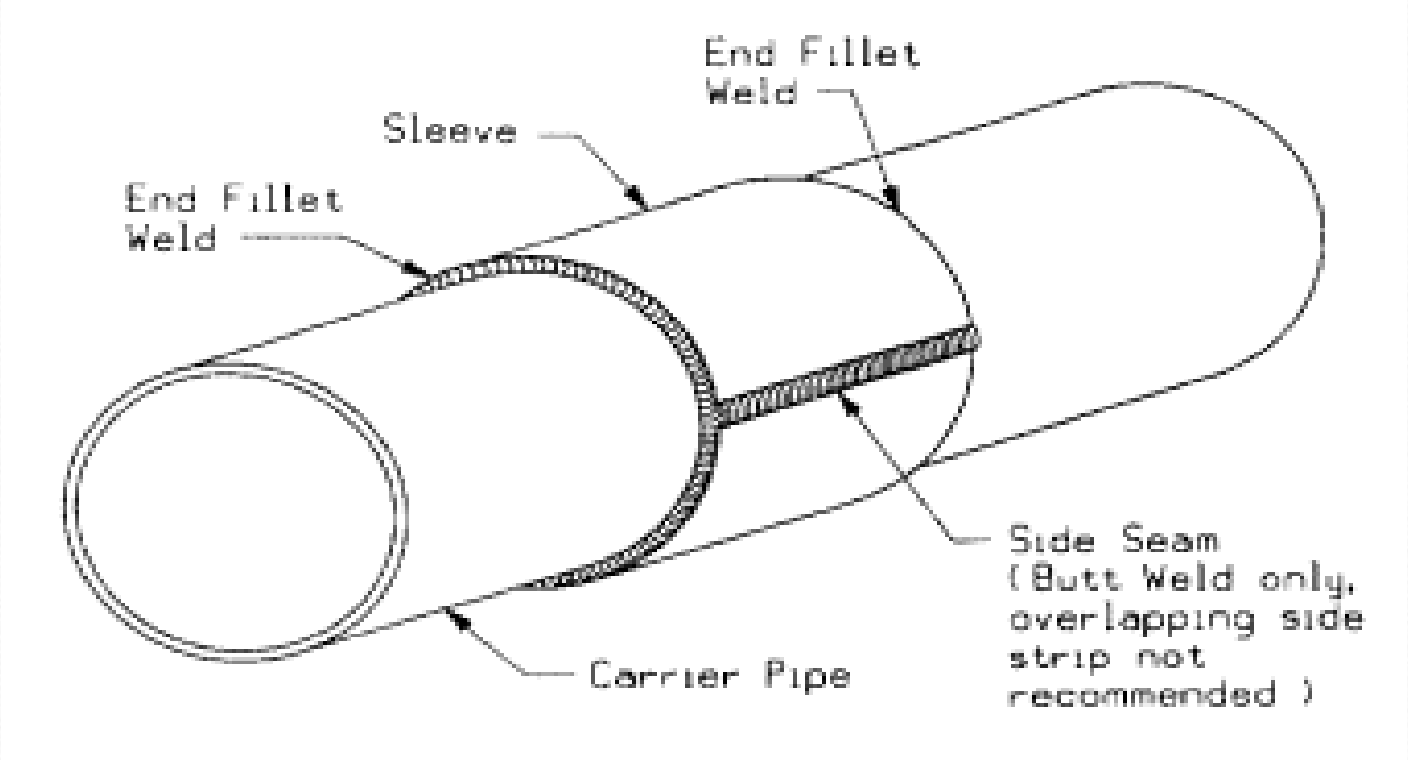
MECHANICAL CLAMPS

CUSTOMISED MECHANICAL CLAMP USED IN VSPL CH. 485 KM

FULL ENCIRCLEMENT SPLIT SLEEVES

Two types of sleeves are available, one with no end closure welds (Type A) and the other with both end closure welds (Type B).

- Reinforces a locally corroded area.



FULL ENCIRCLEMENT SPLIT SLEEVES

- As per GAIL's maintenance guidelines, full encirclement welded ***Type-B*** split sleeves can be used as a permanent repair measure for leaks, dents, external damages, External corrosion and Internal corrosion.
- However for dents & external damage, pipeline surface shall be ground-out and the missing wall shall be filled with incompressible filler.
- Since the full-encircling pressure-containing Type-B sleeve may contain pressure / leak in the event of pipe failure, it shall be designed, fabricated and installed in accordance with the same requirements as specified for the pipeline.
- The sleeve should extend to a minimum of 100 mm beyond the defect and should not be less than 300 mm in length. Sleeve thickness must be greater than or equal to pipe wall thickness
- Ends of the sleeve (with no end closure welds) should be sealed to avoid corrosion in the pipe-to-sleeve annulus.

FULL ENCIRCLEMENT SPLIT SLEEVES

- When used to repair a pipe crack, the crack must be proven stable (will not able to propagate beyond the sleeve).
- End closure welds may be sized to contain thrust force in the event of full separation of the degraded pipe.
- Sleeve thickness (with both end closure welds) sometimes kept twice the pipe wall thickness so that fillet weld leg length is at least twice the pipe wall thickness.
- Sleeves are preferably made of rolled plates – these are lighter, thinner, and have better weldability than forged mechanical clamps.
- Preheating the sleeve before encompassing the pipe achieves a snug compression fit when cooled, to reduce tensile stress.
- Too snug of a fit may increase the defect stress as a result of shell ovality which occurs when the longitudinal seam weld cools and contracts. Hence, when seam weld cools, it is to be ensured that shell does not clamp on pipeline.

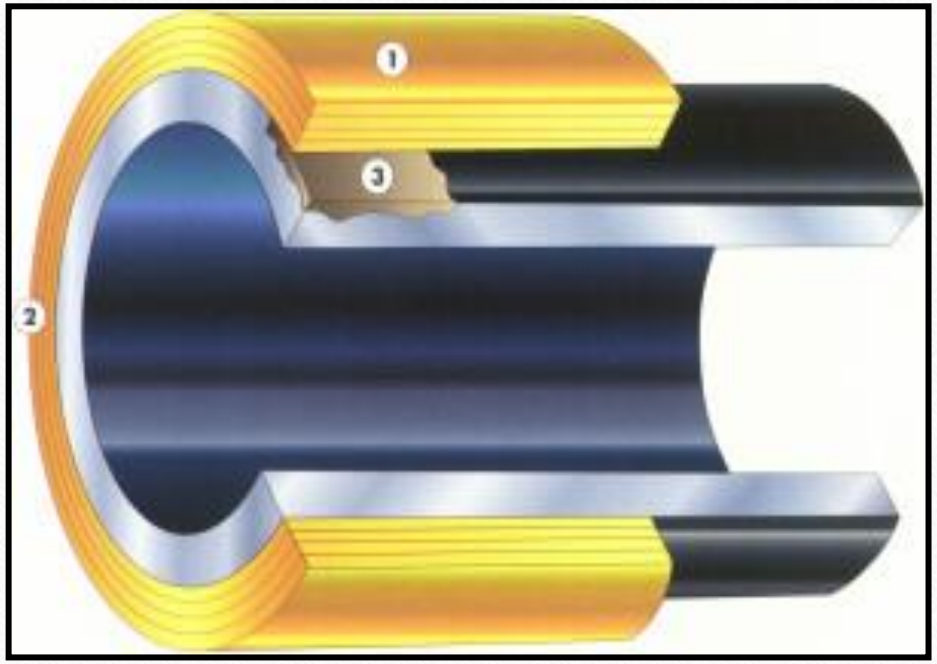
FULL ENCIRCLEMENT SPLIT SLEEVES

- However too large of an annulus gap creates risk of circumferential fillet weld cracking when the end welds are made. Hence, very precision welding is to be done.

FULL ENCIRCLEMENT SPLIT SLEEVES

COMPOSITE WRAP – CLOCK SPRING

Before year 2000, pipeline repair methods were restricted to replacement, or use of full encirclement steel sleeves welded in defective place of the pipe. Since 2000, composite wraps are being used commercially. Composite wraps consists of following three basic components :



1. A high strength glass fiber composite or laminate.
2. An adhesive or resin bonding system.
3. A high compressive strength load transfer filler compound.

COMPOSITE WRAP – CLOCK SPRING

COMPOSITE WRAP – WHEN TO USE

- Suitable for 100 mm (4”) to 1400 mm (56”) pipe diameters.
- Pipeline defects must be carefully analysed. Industry standards : ASME B31G or RSTRENG (modified B31G) to be followed for analysis of defects.
- It is considered as a Permanent repair technique for external, non-leaking defects. However, although it performs well under short term burst tests, but long term behaviour yet to be determined.
- As per GAIL’s maintenance guidelines, composite wraps can be used as a permanent repair measure for Dents, External damages and External corrosion.
- However for dents & external damage, the pipeline surface shall be ground-out and the missing wall thickness shall be filled with in-compressible filler.
- It is applicable to repair of blunt defects (i.e. general corrosion) up to 80% loss of wall thickness.
- NDT shall be carried out to check for cracks/other defects before application of composite sleeve. If required the pipeline pressure may be reduced / depressurized while executing the job.

COMPOSITE WRAP – CLOCK SPRING

COMPOSITE WRAP – INSTALLATION

After excavation and pipe preparation :

- Thoroughly clean defective area, fill gaps in metal loss region with filler material.
- Apply adhesive over filler and wound flexible layers of Clock Spring composite around pipe.
- Apply adhesive or laminating agents (polyester resin) between layers. Use strap to tighten wrap before curing.
- Essentially forms uniform sleeve around pipe. Composite wrap is approximately 300 mm wide, typically 8 layers of wrap are applied for a total thickness of 12.7 mm.
- Typically 2” of wrap must extend beyond damage.
- After mandated drying or curing time and hardness checking, excavation site can be back-filled.

COMPOSITE WRAP – CLOCK SPRING

COMPOSITE WRAP – ADVANTAGES

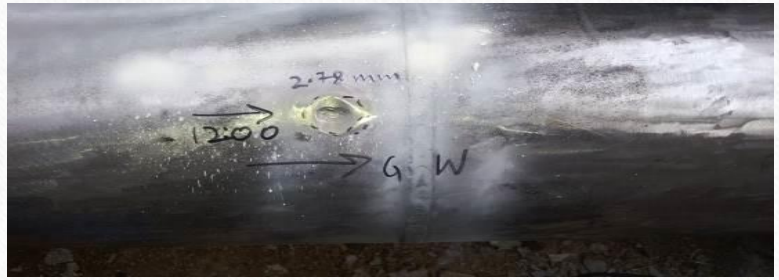
- Quicker and less expensive.
- Does not require welding. Hence, minimal clearance required during installation.
- In-service pipeline repair methodology, no shutdown is required. No LPG venting is required.
- Pipelines can be repaired at full pressure. However, reducing pressure improves quality of repair.
- Installation takes about 30 minutes, curing about 2 hours.
- Site access & preparation issues are minimal.
- Serves as a reinforcement to prevent burst failure of thinned area. Hence, can be used for temporary repair of internal defects also.

COMPOSITE WRAP – CLOCK SPRING

COMPOSITE WRAP INSTALLATION IN VSPL

COMPOSITE WRAP – CLOCK SPRING

COMPOSITE WRAP INSTALLATION IN VSPL (3 WRAPS)



CUT AND REPLACEMENT OF PIPELINE SECTION

LOCATION NO: 1 (CHAINAGE: 1066.068 KM)

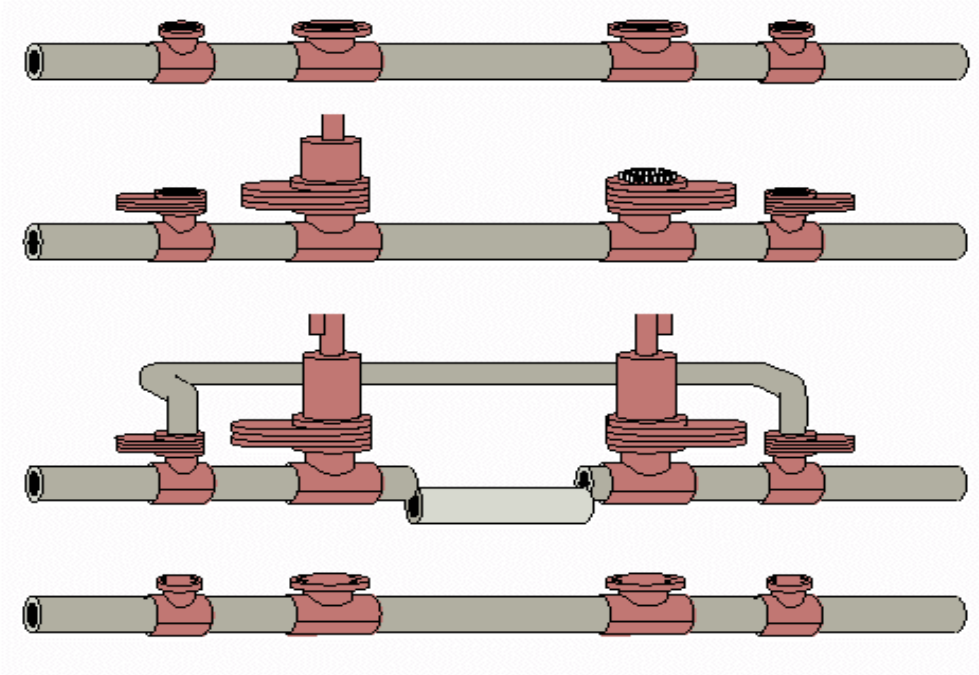
SPLIT TEE FIT-UP

HOT TAPPING IN PROGRESS

HOT TAPPING

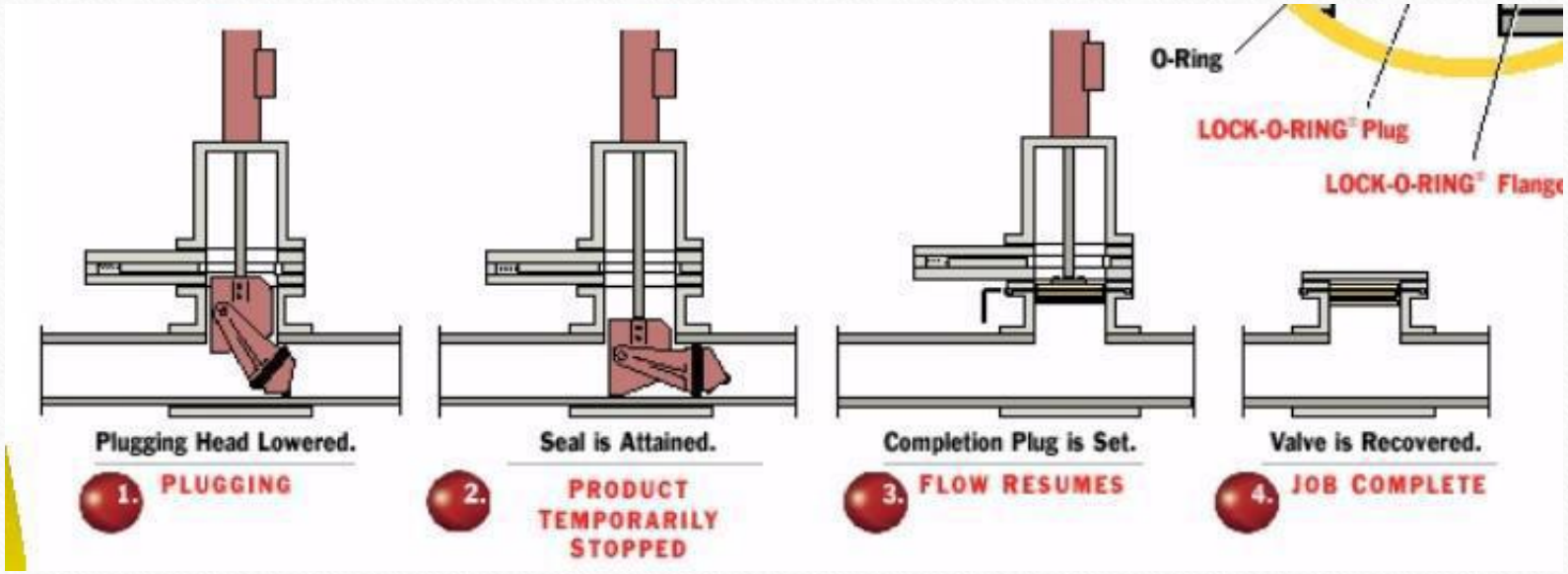
- This method is used to remove a section of pipe containing a defect from an in-service pipeline without disrupting operations – this method is also known as “stopple and bypass”.
- Typical double stopple procedure involves installation of two pairs of split tees with sandwich valves on either side of the damaged section.

Typical Double Stopple Procedure



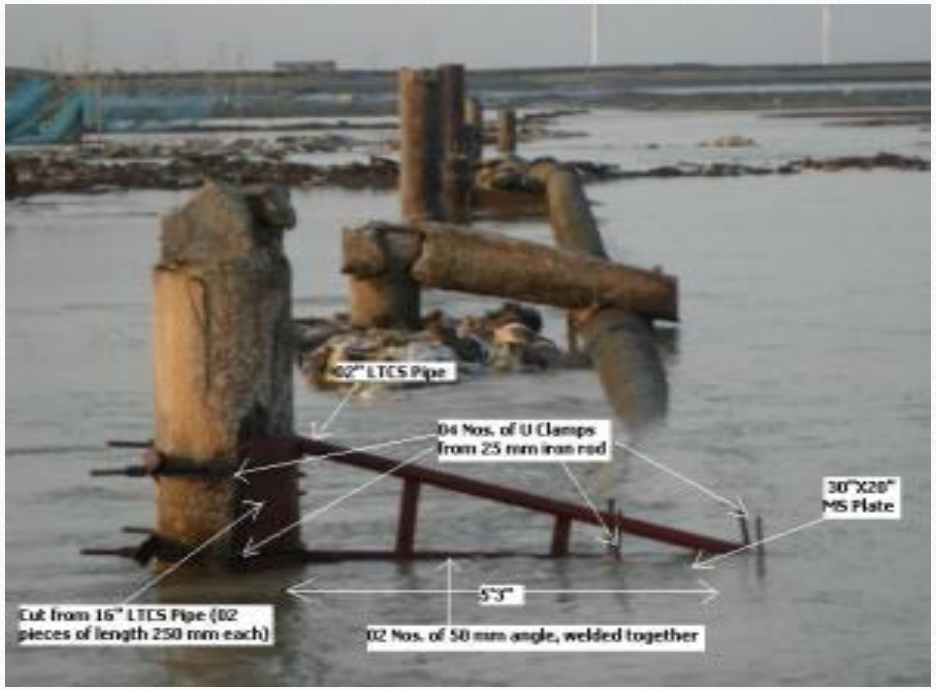
HOT TAPPING

- Hot-tapping is performed through the sandwich valves on each tee.
- Temporary bypass line is then installed between the two outer tees to maintain flow.
- The two inner tees are fitted with stopple plugs which are used to divert flow through the temporary bypass and isolate the damaged section so that it may be removed and replaced with new.



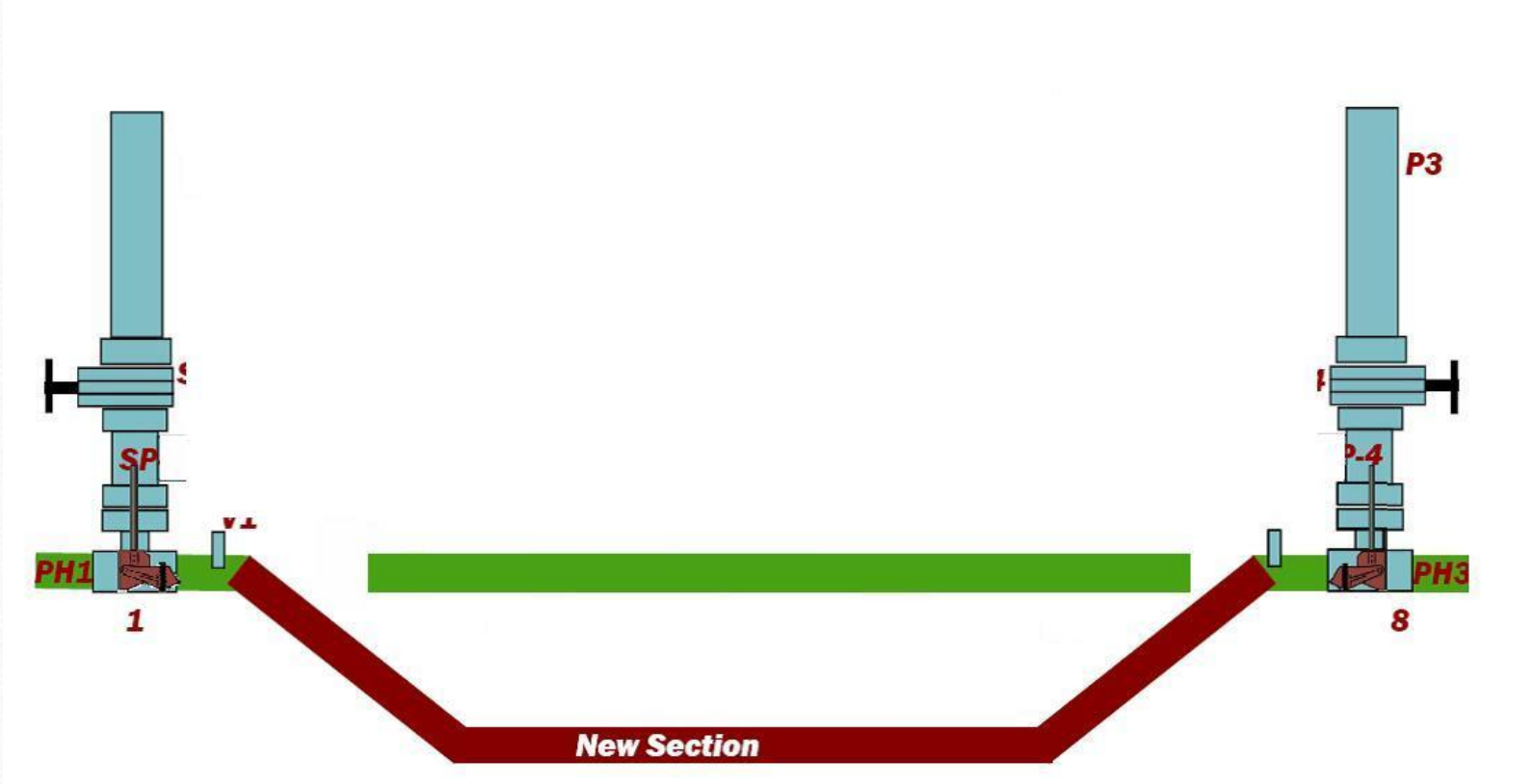
HOT TAPPING (CASE STUDY – 1)

PIPELINE REPLACEMENT AT HADAKIYA CREEK IN JLPL BY HDD AND DOUBLE STOPPLE



HOT TAPPING (CASE STUDY – 1)

PIPELINE REPLACEMENT AT HADAKIYA CREEK IN JLPL – INITIAL HOOK-UP SCHEME (SINGLE STOPPLE)



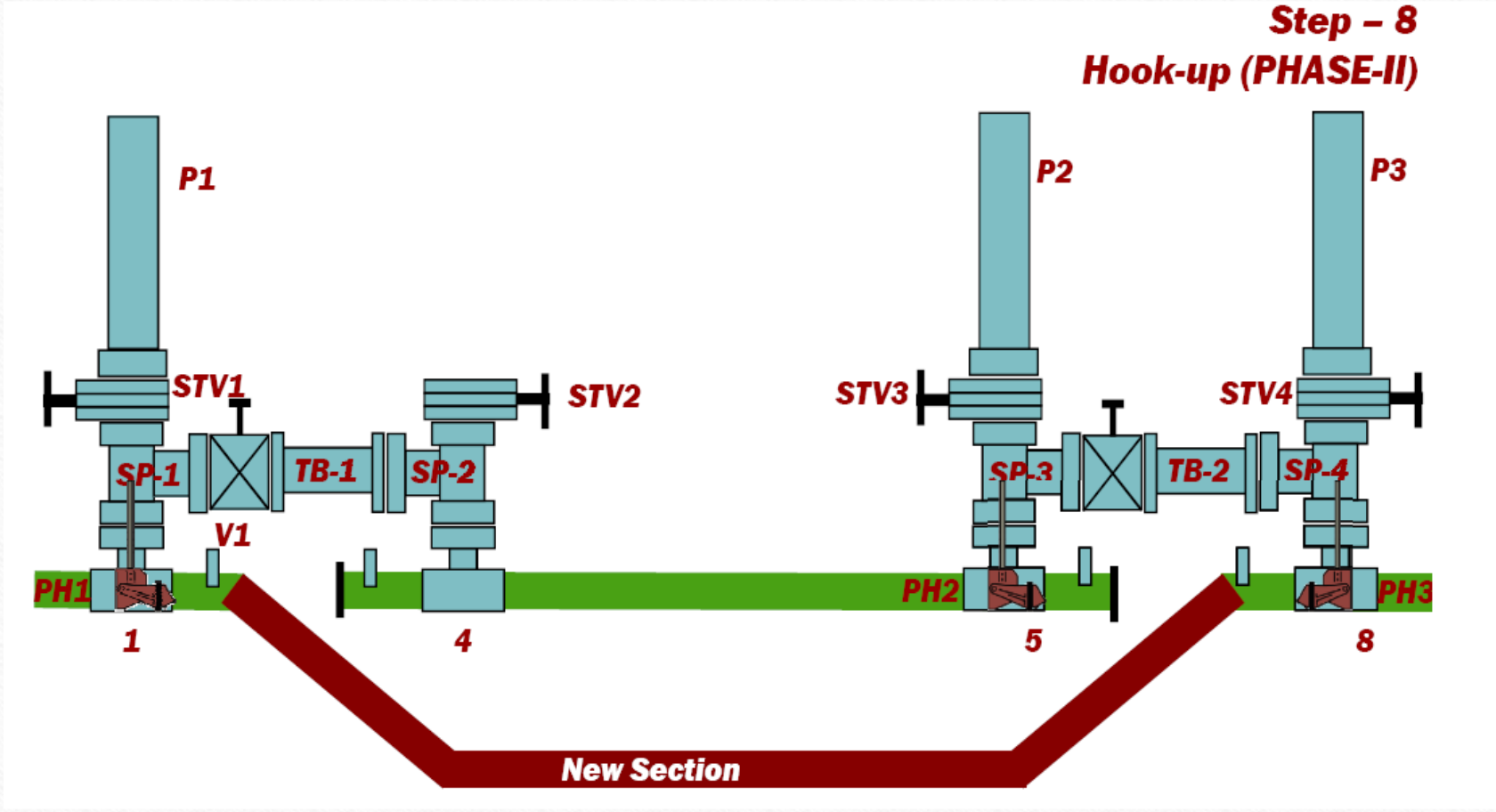
HOT TAPPING (CASE STUDY – 1)

DISADVANTAGE OF INITIAL HOOK-UP SCHEME

- Total shutdown of JLPL line for at least 72 Hrs - there will be no flow between SV-08 to SV-09 section.
- Evacuation of approximately 125 MT LPG from the old section was required which was a very challenging job and an environmental issue.
- Recovery of LPG was possible only if some external arrangement was made like High pressure centrifugal pump, LPG tanker and other associated work.
- Remaining LPG of old line to be removed by cold / hot flaring through mobile flare before cutting and welding for hook up of new line with old line.
- Some major safety issues were also cause of concern. Cold flaring of LPG vapor in open atmosphere was extremely risky due to adjacent highway, nearby villages, etc..
- Apart from the operational / safety issues, financial issues were also involved. Total cost of LPG to be flared was approximately 53 lacs. It was not sure how much LPG out of total qty. of 125 MT could be evacuated before starting of Hook-up activity.
- Jamnagar to Samakhiali pipeline section would have been under shut down for at least 72 Hrs. resulting revenue loss of approximately Rs. 1.60 Crore.

HOT TAPPING (CASE STUDY – 1)

FINAL HOOK-UP SCHEME - DOUBLE STOPPLE METHOD



HOT TAPPING (CASE STUDY – 1)

ADVANTAGE OF FINAL HOOK-UP SCHEME

- Under this method, most of the LPG was transferred to new pipeline, venting was minimized.
- After hook-up of new HDD section, approximately 120 MT of LPG from old section was evacuated and transferred to new section safely.
- Saving of costly fuel - approximately Rs. 53 Lac.
- Safety in the process as most of LPG could be recovered through this process.
- Arrangement of Tankers was not required for Loading of LPG into tanker.
- Shut-down of JLPL was avoided .
- Minimum LPG venting into the atmosphere by cold flaring. Hence Environmental Impact due to venting of large quantity of LPG into atmosphere was avoided.

HOT TAPPING (CASE STUDY – 1)

SITE PHOTOGRAPHS OF HADAKIYA CREEK

HOT TAPPING (CASE STUDY – 2)

CLAMP REPLACEMENT AT VSPL CH. 485 KM BY DOUBLE STOPPLE

HOT TAPPING (CASE STUDY – 2)

CLAMP REPLACEMENT AT VSPL CH. 485 KM BY DOUBLE STOPPLE

HOT TAPPING (CASE STUDY – 3)

PIPELINE RE-ROUTING AT JLPL CH. 1067 KM BY DOUBLE - DOUBLE STOPPLE

HOT TAPPING (CASE STUDY – 3)

PIPELINE RE-ROUTING AT JLPL CH. 1067 KM BY DOUBLE - DOUBLE STOPPLE

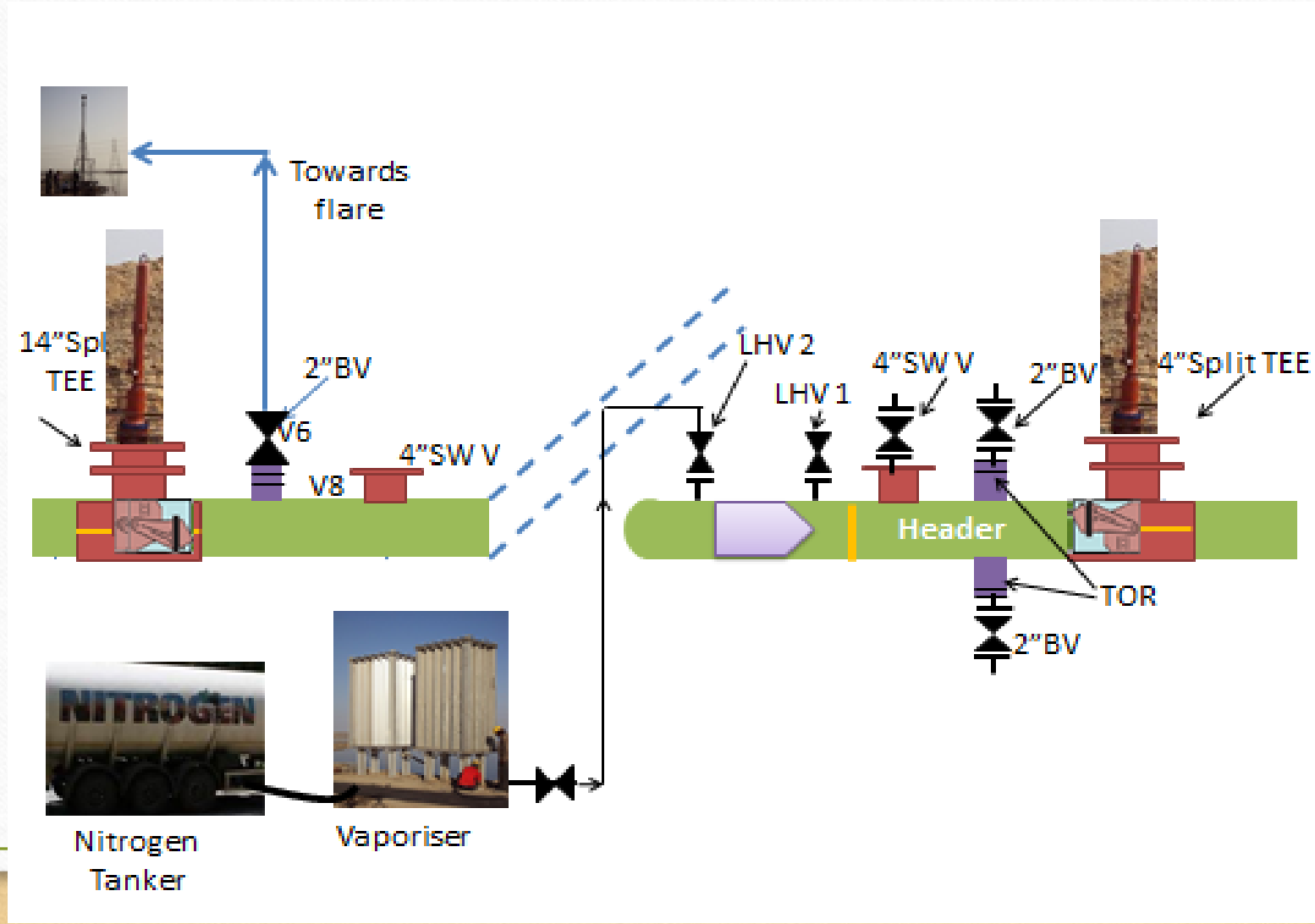
SELECTION OF PERMANENT REPAIR METHODS

Sl. No.	Type of Defect	Grinding	Type-B Sleeve	Composite Sleeve	Bolt on Clamp	Hot Tap
1.	Leak (from any cause)	No	Yes	No	Yes	Yes
2.	External Corrosion	No	Yes	Yes	Yes	Yes
3.	Internal Defect or Corrosion	No	Yes	No	No	No
4.	Gouge or other metal Loss on Pipe body	Yes	Yes	Yes	Yes	Yes
5.	Arc Burn, Inclusion or lamination	Yes	Yes	Yes	Yes	Yes
6.	Smooth Dent	No	Yes	Yes	Yes	No
7.	Dent with Stress Concentration on seam weld or Pipe Body	No	Yes	Yes	Yes	Yes
8.	Dent with Stress Concentration on Girth weld	No	Yes	No	Yes	No
9.	Shallow Crack	Yes	No	No	No	Yes
10.	Deep Crack	No	No	No	No	Yes
11.	Girth Weld Defect	No	Yes	Yes	Yes	No
12.	Wrinkle, Buckle, Defect in or near an ERW Seam	No	No	No	No	No


Thank You

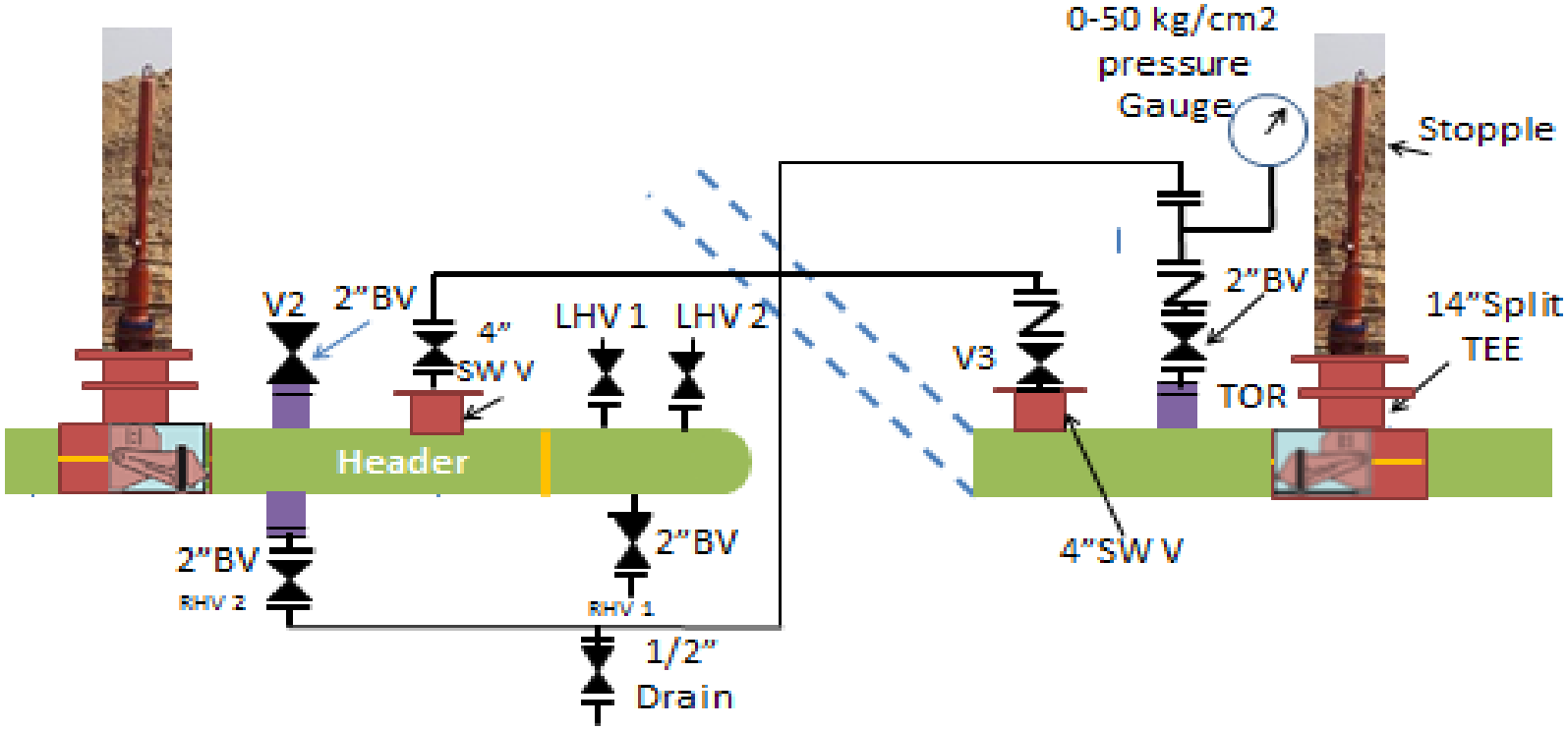
Pipeline Repair Techniques

LPG EVACUATION SCHEME AT SAMAKHIALI END



Pipeline Repair Techniques

LPG EVACUATION SCHEME AT JAMNAGAR END



REMOVAL OF CORROSIVE WATER (1.48 KM to 1.75 KM) FROM LONI SPUR LINES

BEFORE

AFTER

LOWERING OF 12” DIA IN-SERVICE LPG P/L AT 4 LOCATIONS NEAR RT - LONI

P/L Position before Lowering
(CH. 1172.80 KM)

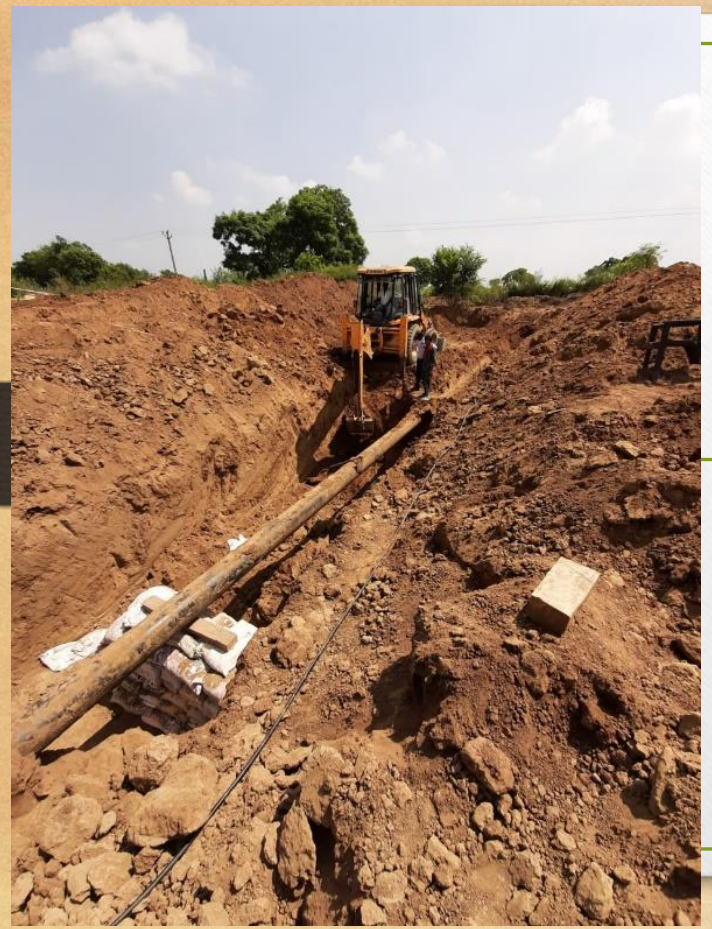
Lowering under progress

LOWERING OF 12” DIA IN-SERVICE LPG P/L AT 4 LOCATIONS NEAR RT - LONI

Strain measurement under progress

Final position after lowering

LOWERING OF 12” DIA IN-SERVICE LPG P/L AT CH. 1169.25 KM NEAR RT-LONI



P/L Position before Lowering

Lowering under progress

Position after Lowering

INSTALLATION OF PRECAST BLOCK TO PREVENT FROM 3RD PARTY DAMAGE

Before

After